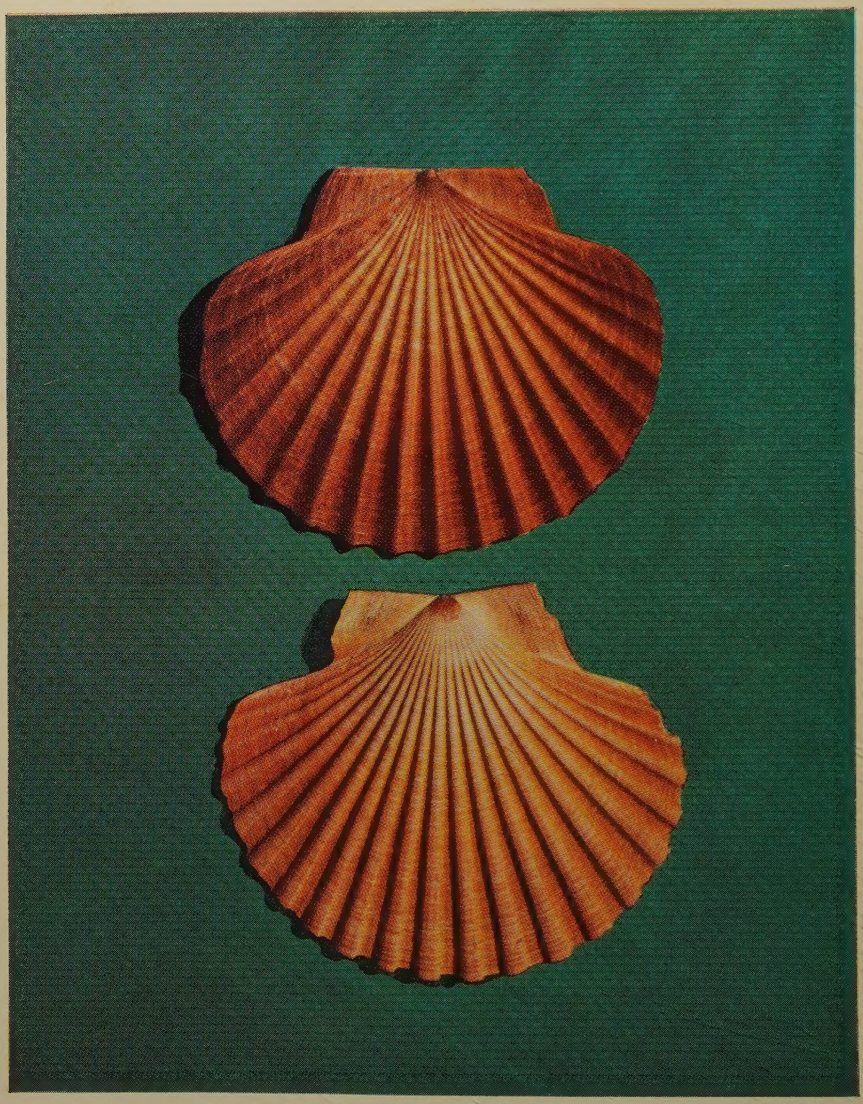

SAN DIEGO SCALLOP, *Pecten diegensis*. Photo by Herb Phillips, San Pedro

STATE OF CALIFORNIA
DEPARTMENT OF FISH AND GAME
MARINE FISHERIES BRANCH

FISH BULLETIN No. 90

# Common Marine Bivalves of California

1857 60

By
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JOHN E. FITCH
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# INTRODUCTION

## PURPOSE

This bulletin was written with three objectives in mind. First, it is designed to provide authorized names for the more common edible marine bivalve mollusks of California in the hope that these names will be used not only by the sportsmen but by the fishing industry. Secondly, it is an attempt to assess the economic importance to the State of these bivalves by putting on record the extent and location of the available bivalve-producing grounds, the number and abundance of the edible species, and, by contributing to a knowledge of their life histories, lay the foundation for such protective legislation as may in the future be found necessary. Thirdly, it proposes to make available to the amateur clam digger and amateur naturalist a means of identifying the more common and important bivalves. It is meant as a guide for any person interested in bivalve mollusks regardless of his technical knowledge and background, so scientific terminology is avoided wherever possible.

## SCOPE

Weymouth (1920) and Bonnot (1940) have previously published papers on edible California bivalves. The former included descriptive material on 43 species, a majority of which were illustrated with photographs. Bonnot, on the other hand, discussed 32 species in some detail and illustrated most of these with pen and ink sketches. The present manuscript, enlarging upon both of these papers, covers 60 of the more common clams, mussels, scallops, and oysters of the State.

Over 400 species of bivalves are known from the coast of California, but many of these are, of course, too small or too rare to be of any economic value. Consequently, the 60 species illustrated and discussed represent only a fraction of the total known. The criterion used in the selection of these 60 species was whether or not the bivalve in question would probably be met in a market, or be dug for food, for fish bait or by accident. Few are common or conspicuous enough to be found in all clam digging localities of the State, but whether abundant or rare, extensive or restricted in range, it is felt that of the edible species these are probably found and used most frequently.

# THE NAMING OF BIVALVES

## COMMON NAMES

In California there is a constant and growing demand for common names; particularly names that can be applied to those plants and animals which contribute much to the natural wealth of the State. The need for these common names is not always apparent, but a consistent terminology is of immeasurable importance to the work of the California Department of Fish and Game. The Marine Fisheries Branch, in order to follow the many fisheries of the State, must know the catch of each kind of bivalve. The Fish and Game Commission and the State Legislature, in order to legislate and regulate these fisheries must have stable names and sound information from which to render proper decisions. The same clam may have different vernacular names in different parts of the State and a name applied to one species or kind of clam in one region may be applied to a different bivalve in another region.

Several official common names have been changed in this publication. In a few cases, names have been coined where none previously existed. Some names have been discarded, either because they were applied to a number of species or because it was felt the time has arrived when an attempt should be made to clarify the true relationships of some of the species which had names implying false relationships. Foremost of these and perhaps the most radical name change is the application of "littleneck clam" to those species previously known as "cockles" but which are not even faintly related to the true cockles. Three of the true cockles have been included in this paper. The name "chione" (pronounced "Ki-own-ee") is here used for the three species previously called "hard shell cockles" and "jingle" is used instead of "rock oyster." Not only are these latter two neither "cockles" nor "oysters" but they do not even closely resemble the two. In time, these changes, when incorporated into our fish and game laws, should do much toward making these laws more understandable and, therefore, more readily enforced. Too, these new names are in closer harmony with the names applied to similar species in other states and countries and when associated with our species should avoid much confusion among California's future populace.

## SCIENTIFIC NAMES

From the foregoing, it becomes evident that a common name cannot be depended upon to provide a term which will separate a given animal from any other. Herein lies the reason for and the value of scientific names. Scientific names are often regarded by those unfamiliar with them as unintelligible and, consequently, useless appendages designed by the scientist for no good reason except, perhaps, the confusion of the layman. They serve, however, definite and useful purposes, especially in classification. Classification, in turn, serves a twofold purpose. On the practical side, a system of classification facilitates the identification of

species. On the theoretical side, classification shows the relationships or supposed kinships of groups concerned.

Every man has recognized at some time or another that the living objects around him can be divided into two major groups: plants and animals. These the scientist labels "kingdoms." In the animal kingdom, the average individual has undoubtedly realized that some animals have backbones while others do not (the "vertebrates" and "invertebrates" of the scientist). Among those having backbones, the nonscientist is easily able to sort out certain groups in which all of the individuals closely resemble each other (snakes, fish, birds, mammals, etc.). Among the mammals (animals which have mammary glands for suckling their young) there are again those which all closely resemble each other: rodents with sharp incisor teeth which are used for gnawing (mice and rats, beavers, rabbits, porcupines, etc.); carnivores with flesh-eating habits, powerful jaws and strong canine teeth (lions and tigers, dogs and wolves, hyenas, etc.), and so on. Among the rodents of the world are several kinds of porcupines, several kinds of beavers, many kinds of mice and rats, many kinds of rabbits, etc. All rabbits look the same regardless of the country to which they are native. They have the same kind of legs, ears, tails, and noses and wherever a person saw one he would know it was a rabbit. The average hunter or outdoorsman could, without difficulty, make an even finer distinction among the wild rabbits (jackrabbits, cottontails and brush rabbits), and most youngsters can separate tame rabbits into angoras, chinchillas, and so on. Some hunters could state with certainty that there are several kinds of jackrabbits and actually enumerate the differences. In forming these numerous subdivisions or groups, the layman has used a complete classification system; the technically trained individual uses exactly the same system but applies scientific names to all the common names and gives names to the different groups or categories:

| *Nontechnical terminology* | *Category* | *Scientific terminology* |
|---|---|---|
| 1. Animals | Kingdom | Animalia |
| 2. Having backbones | Phylum | Chordata |
| 3. Mammals | Class | Mammalia |
| 4. Rodents | Order | Rodentia |
| 5. Rabbits | Family | Leporidae |
| 6. Jackrabbits | Genus | *Lepus* |
| 7. Blacktailed jackrabbit | Species | *californicus* |

Since the relationships which distinguish the different groups of bivalves are more obscure to the average individual, rabbits were used to illustrate the basic conception of classification. However, the identical seven categories are used by the scientist for the classification of all animals. For a typical bivalve, the California sea-mussel, these would be:

| *Nontechnical terminology* | *Category* | *Scientific terminology* |
|---|---|---|
| 1. Animals | Kingdom | Animalia |
| 2. Having soft bodies | Phylum | Mollusca |
| 3. Hatchet-footed | Class | Pelecypoda |
| 4. Transverse hinge teeth | Order | Prionodesmacea |
| 5. Mussels | Family | Mytilidae |
| 6. Sea-mussels | Genus | *Mytilus* |
| 7. California sea-mussel | Species | *californianus* |

Every kind of animal known to man has had a scientific name of two parts given to it (a generic name and a specific or trivial name) and this double name, once used for an animal, can never be given to any other kind of animal at a later date. All jackrabbits are in the genus *Lepus,* but there is only one *Lepus californicus* and that is the blacktailed jackrabbit. The words should be italicized and only the generic name begins with a capital letter. In this present manuscript the name of a man, printed in Roman type, and a date, follows the scientific name. This is the name of a person who first described the species and the year in which he described it. When this name and date are enclosed in parentheses it indicates that someone has since studied that particular species and placed it in a different genus from that decided upon by the original describer.

The naming of animals is subject to certain rules laid down by the International Commission on Zoological Nomenclature. With scientists working throughout the world, some confusion and duplication is inevitable. Disputes which may arise as a result are settled by rulings of this commission.

Scientific names must be rendered in Latin or latinized form. In many instances the names are derived from Greek or Latin and when broken down describe some character of the animal in question. Other animals have been given names to indicate geographic localities in which they were found and still others were named for men who made important contributions to the field of science. Usually a well-made scientific name is a treasure house of meaning, carrying valuable clues to identification, rich allusions to scientific history and discovery, and seldom is a so-called "nonsense name" applied to a species. The scientific name of the rock scallop, *Hinnites multirugosus,* though formidable to observe, quite aptly describes the scallop. *Hinnites* is derived from the Latin word for "mule" and refers to the tenacity of the scallop in its attachment to rocks and other solid objects. The specific name *multirugosus* is derived from two Latin words meaning "much" and "wrinkled" which appropriately describes the outside of the two valves.

The specific names *diegensis, virginica, peruviana, californica, bodegensis,* and *pacifica* refer to the geographic localities of San Diego, Virginia, Peru, California, Bodega, and the Pacific Ocean. Finally, the specific names *nuttalli, gouldi, hemphilli,* and *pilsbryi* were given in honor of Nuttall, Gould, Hemphill, and Pilsbry, who contributed much to the advancement of science.

## GENERAL INFORMATION

Clams, oysters, and scallops have two shells and are hence called bivalves. These have adopted many ways of life. Some burrow into sand, mud, rocks, or wood; some become attached to rocks or other solid objects; others are free-living and able to swim for short distances.

In identifying bivalves, various characteristics of the shell are usually used. Because of the many types of environment in which a clam may

become lodged, considerable variation exists in the external markings of the shell, but the interior markings and structures are less likely to vary and are thus of greater value for identification purposes.

The beauty and variety of form of the shells of bivalves early attracted the attention of students, so that thousands of species have been described and named. The first writers based their descriptions on the shells alone, but later work showed that the shell itself could not always be depended upon to show the true relationships. Accordingly, the present day descriptions of groups include anatomical features of the soft parts which were often disregarded by earlier students.

## HABITS AND HABITATS

The localities in which bivalves live are as varied as the localities in which the waters of the seas are found. On the open sandy beaches exposed to pounding surf and shifting sand are found Pismo, razor, and bean clams. In the quieter water off these beaches live the white amiantis, some of the horsemussels, the deep water gari, and many others. Attached to rocks in the pounding surf are the mussels and chamas; burrowing in these same rocks are several of the piddocks. Under cobble and boulders in less exposed situations of the open coast intertidal zone are the common littlenecks and gapers, while just offshore, attached to rocks, shells and other objects are the jingles.

In the coarse sand of swift running bay, slough, and estuary entrances the purple clam is most numerous and near shore can be found the tellens.

Inside the bays in the quieter waters, the most common California bivalve is undoubtedly the gaper. In the southern bays the littlenecks and chiones are almost equally abundant, while in the northern bays the Washington clams take their place. In the muddy areas of the southern bays, scallops are often encountered lying in the pools of water left at low tide. Throughout the entire State the bent-nose clam is the most typical inhabitant of these muddy areas. Attached to pilings, docks, roots of marsh grasses and almost any solid object in these sheltered bays and estuaries are the bay mussels.

Finally, in the central and northern part of the State, at the extreme ends of these inlets of the sea, one finds the soft-shell clam which seems to require water not quite so salty as do most bivalves.

The scallops, with the exception of the rock scallop, may be found moving about in the water a few feet off the bottom or resting on the bottom. Rock scallops, jingles, oysters, mussels and chamas are attached to various objects and seldom is the animal even partially buried. The horsemussels and cockles nearly always have a portion of their shell exposed above the mud or sand in which they live.

A few of the many clams which are found within a few inches of the surface are the bean, Pismo, common and Japanese littleneck, chiones,

and white amiantis. At depths of a foot or so occur the thin-shelled littleneck, purple clam, Washington clams and most of the piddocks. Finally, at greatest depths, often as much as three and four feet, one finds the geoduck (pronounced "gooeyduck") and gaper.

The northern razor clam, though usually located close to the surface, may burrow a foot or two before being captured and the jackknife, rosy razor and sickle razor clam which are also located close to the surface will, if disturbed, retreat rapidly to the bottom of a permanent burrow a distance of a foot or more.

## ANATOMY

The soft body of the bivalve is enclosed in, and is protected by, the two chalky shells or valves. The shell is composed of three layers of material. The outside layer is of a horny composition and is so thin that in most species it is worn off except around the edges of the shell where new growth may have just taken place. This layer is called the periostracum and in such clams as the Pismo, razor, and purple it resembles a thin coat of varnish which cracks and peels when the shell is exposed to direct sunlight. In some of the horsemussels the periostracum is hairy in appearance. The middle layer is called the prismatic layer and makes up most of the thickness of the shell. The inner layer, often nacreous, is very hard, and in some species such as mussels is very shiny.

The shells are joined along the back or dorsal part of the clam by means of a horny elastic material usually visible from the outside and termed a hinge ligament. This ligament tends to spring the valves apart when the body of the clam is removed from the shells. In the living animal the shells are held together by two powerful adductor muscles, one at each end of the body. (In scallops, jingles, and oysters there is only one adductor muscle.)

Near the hinge ligament and usually in front of it are knobs or projections of the shell called the umbones or umbos. The umbo (singular) or beak is the oldest part of the shell and the shape of the bivalve when it was very small is often indicated by growth lines near the hinge at the tip of the umbo.

Also on the exterior of the shell is a series of lines whose prominence varies with the species. Some are concentric about the umbones and others radiate out from the umbo toward the ventral edge of the shell. Concentric lines occur on nearly all species but with varying degrees of prominence, while radiating lines occur only on a few.

The heart-shaped circumscribed or depressed area in front of the beaks on such clams as the banded and wavy chiones and the quahog is the lunule. The depressed area posterior to the beaks and near the hinge line, is known as the escutcheon. This escutcheon is not always distinct; it is most noticeable on the giant smooth cockle and the banded and wavy chiones.

The inside of the shell is usually quite smooth except for scars caused by the attachment of muscles to the shells. The adductor muscle scars are usually more or less circular in outline and are found at the upper part of the ends of the shells. Connecting these is a finer line called the pallial line which marks the place of attachment of the mantle to the shell. In the posterior portion of the shell the pallial line may be indented to form the pallial sinus.

Also on the interior of the shell near the umbo is a heavy ridge which may be studded with projections or teeth of various sizes, shapes, and combinations. The shape of these hinge teeth is constant for each species and their purpose is to form a locking device to prevent slipping of the valves when closed.

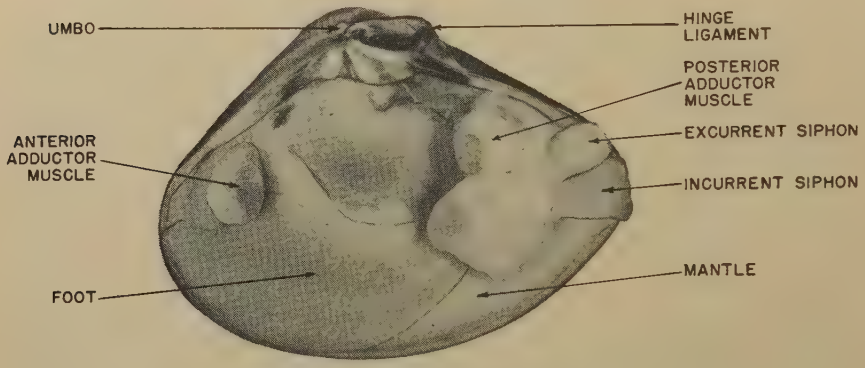


FIGURE 1. Internal anatomy of the Pismo clam. Left valve and mantle removed

Just inside the shells and completely enclosing the soft body of the animal are two lobes of the mantle. Each lobe of the mantle secretes a valve and the mantle grows as the shell increases in size. The smooth inside part of the shell is secreted by the whole mantle while the middle and outer layers, including periostracum, frills, ridges, and colors, are secreted by the thickened outer edge of the mantle.

In the scallops the thickened outer edge of the mantle is made up of a series of filaments or tentacles which are sensitive organs of touch. Near the bases of some of these tentacles, at evenly spaced intervals, are a number of minute eyes or ocelli, each on a short stalk. These eyes have many of the same parts as a human eye and are quite sensitive to light. With these eyes the scallop is able to detect the presence of some foreign object or enemy.

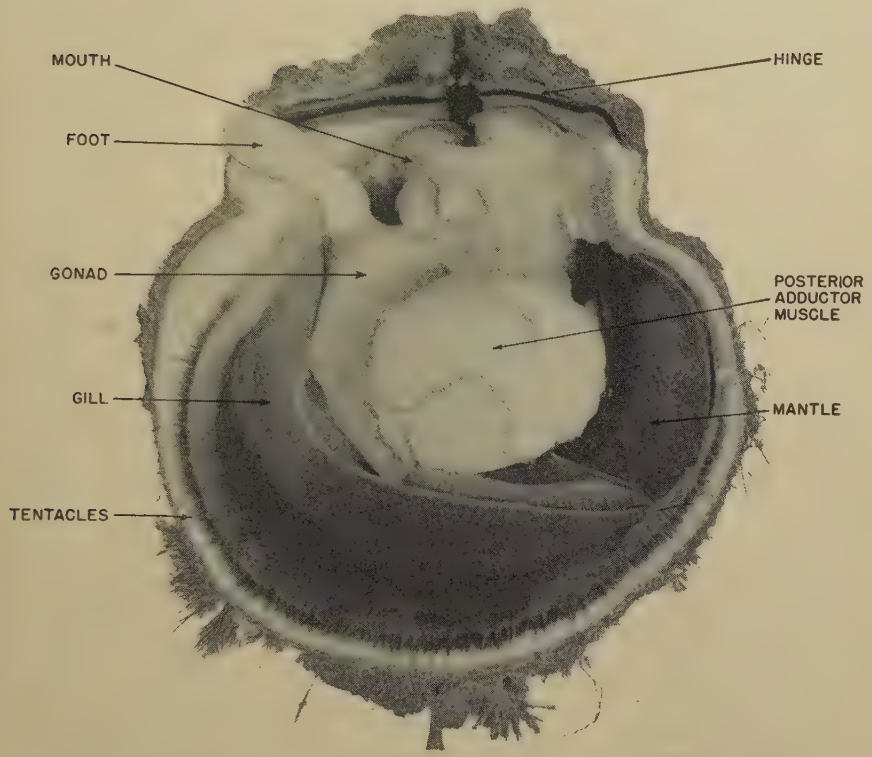


FIGURE 2. Internal anatomy of the rock scallop. Left valve and mantle removed

Siphons (modifications of the posterior mantle edges) are present in the majority of bivalves. In those species that possess siphons, the mantles are fused together at various points along their edges, except posteriorly, where there are two openings, the lower or ventral one being the incurrent opening and the upper or dorsal one being the excurrent opening. In most of the clams these openings are fused together in the form of tubes. In oysters, mussels, and scallops, however, the mantle edges are open and hair-like cilia on the gills move in such a manner as to establish a current of water flowing through the bivalve.

A hatchet-shaped, fleshy organ of locomotion, the foot, extends downward on the median line between the two pairs of gill flaps. In this position it can be protruded between the two shells for locomotor or digging purposes. In the mussels the foot spins a strong, coarse, hairy byssus, with which the mussels cling to more or less solid objects.

The paired gills are found in the mantle cavity on either side of the base of the foot. These have somewhat the appearance of plume-like feathers and are usually slightly darker than the foot. In clams, the reproductive organs, which may be seen by slicing lengthwise through the foot, are the soft, whitish or yellowish part through which the intestine loops. The female reproductive organs are sometimes pinkish in color, as with the bean clam, affording an easy means of distinguishing the sexes. The large, dark mass in the hinge area which is embedded in the base of

the foot is the liver. Frequently, when fresh clams are being cleaned, an amber-colored, rod-shaped organ up to an inch or more in length pops out of the visceral mass. This is not a worm or parasite, but the crystalline style which aids the clam in its digestive processes.

## LOCOMOTION

The larvae of bivalves are all free swimming. Upon completion of this free-swimming larval period, most bivalves settle down to a comparatively inactive existence. The scallops, a highly specialized group, retain their ability to swim even after transformation into young or adult stages. Of those discussed in this paper all but the rock scallop are able to swim throughout their life. The rock scallop, after a free-swimming period of about a year, attaches itself by the right valve to a rock or other suitable anchorage and then finishes out its life in a fixed position. The swimming of scallops is actually a type of jet propulsion resulting when the two valves are brought quickly together, forcing water out through openings near the hinge. The distance traveled with each contraction of the valves seldom exceeds a couple of feet.

The jackknife clam moves rapidly up and down in a burrow as do the clams in the genus *Solen*. These clams are also said to be able to jump a foot or more through the water by violent contraction of muscles when the foot is extended.

The littlenecks, chiones, and, to a lesser extent, the Pismo clam can move horizontally through the mud and sand by extending the foot ahead and then drawing the body after it. Such clams seldom move more than three or four feet at a time, often in a half circle, leaving a V-shaped track behind them.

The chamas and some oysters are solidly cemented to the substrate and do not move of their own volition. Piddocks, though usually confined to hard clay and rocks, are capable of a circular motion which aids in drilling their burrows larger and deeper. For the most part, however, the movements of bivalves are rather limited and restricted.

## FEEDING AND NUTRITION

In life when a bivalve assumes a normal feeding position, the shells are opened slightly and the edges of the mantle are extended to the margin of the shell. The siphons are extended and a current of water is drawn into the mantle cavity through the incurrent opening. This water not only aerates the gills but furnishes quantities of microscopic animals and plants for the bivalve's food. Waste matter, the products of respiration, and the reproductive products are expelled into the water through the excurrent opening.

Most bivalves are detritus feeders or scavengers but some feed almost exclusively on plankton. When the surface of the mud of a bay, slough, estuary, or the ocean is disturbed, a grayish turbidity results. The material causing this turbidity consists of decaying organic matter which

is rich in bacteria, protozoa, nematode worms, and many other microscopic organisms. This sediment, or detritus, often constitutes the principal source of food for burrowing or surface bivalves. Often more than half of the contents of stomachs and intestines of detritus feeders is sand and silt.

When feeding begins, mucus is secreted either at the upper edges of the gills and carried in a sheet by the frontal cilia to the free edges of the gills or it is secreted more or less uniformly over the entire surface. This mucus sheet intercepts all particles from the current of water which passes through the gills and is so efficient that it can filter particles of extreme minuteness, including the smallest bacteria. The food-laden mucus is carried in strings along the edges of the gills to the labial palps (fleshy appendages on each side of the mouth). The palps remove all undesirable particles and allow the rest of the material to pass intact with the strings of mucus directly into the stomach. A considerable quantity of water must be strained each day by the various bivalves in order to obtain enough food to carry on the necessary life processes. It has been estimated that a single Pismo clam three inches in diameter strains about 5,800 gallons of water a year. An adult eastern oyster will pump from two to seven gallons of water per hour (nearly 1,500 times its own weight) and if not exposed at low tide it will feed more than 22 hours out of every 24. When the water temperature is around 65° F., food taken by an oyster will pass the entire intestinal tract in 80 to 150 minutes.

## GROWTH

Most bivalves grow continuously throughout their lives. With growth the shell not only thickens but increases in diameter and the weight of the entire animal becomes greater. The rate of growth can be accurately measured for individual species and for those species which have been studied, it has been found to vary from month to month and season to season. The greatest increases usually occur during spring, summer and early fall months with a definite slowing down during the late fall and winter months. Growth rates vary on different beaches for the same species and, in fact, frequently on the same beach at localities just a mile or two distant from each other.

For most species the average yearly increase in diameter is greatest during the first several years, depending upon the longevity of the species in question. The life span of the bean clam seldom exceeds two full years. On the other hand, Pismo clams have frequently attained ages between 20 and 35 years. Other extreme ages for some of the commoner species are: razor clams 15-17 years, littleneck clams 7-10 years, and geoducks 15 years. Of the nearly 400 kinds of bivalves which have been recorded from California waters, some probably live longer than the 35 years reached by the Pismo clam, while others may not live as long as the bean clam.

Among those species covered in this report, the Pacific oyster and rock scallop probably attain the greatest diameter (10 to 12 inches). The bean clam, with a maximum length of slightly over one inch, is the smallest, while the geoduck, gaper, and smooth giant cockle contain

more meat (including fluid) than any of the other species. A quahog will reach a length of two inches in two and one-half years, and two and one-half inches in three and one-half years, but is said to require 16 years to reach a length of four inches.

## REPRODUCTION

### SEX

Among the more than 10,000 known species of bivalves may be found every grade of sexual differentiation, from species in which the sexes are strictly separate to those that are almost invariably functionally hermaphroditic. As a group, however, bivalves are predominantly of separate sexes with relatively few hermaphroditic species.

The majority of the 60 species covered in this manuscript have not been studied thoroughly enough to state with certainty their methods of reproduction. Among those which have been investigated, the speckled scallop and the basket cockle are strictly hermaphroditic, with eggs and sperm being produced simultaneously in adjacent follicles. In the quahog nearly all individuals are males when but a few months of age; following this initial male phase the individuals are, with few exceptions, either male or female with approximately equal numbers of each sex.

An individual native oyster usually has a short initial male phase followed by a longer female phase and may in some instances have a second male phase the same season. A majority of Eastern oysters are males their first year, nearly equally divided into males and females their second year, and predominantly females as they become older. Finally, giant Pacific oysters have been found to alternate sexes, changing from male to female and back to male during successive spawning seasons.

Those species in which the sexes are strictly separate include the ribbed horsemussel, soft-shell clam, California sea-mussel, bay mussel, bean clam, and Pismo clam. In these species males and females occur in approximately equal numbers.

To the writer's knowledge, there is absolutely no method to determine the sex of a bivalve from the outside of the shell. With but few exceptions a careful microscopic examination must be made to determine sex. In the bean clam and rock scallop the gonads of the females are pinkish or reddish in color and those of the males are buff or cream colored, but in most species there is no color difference between the gonads of the two sexes.

### MATURITY AND SPAWNING

Some bivalves mature sexually and spawn within a few months after setting; however, most of the species discussed in this paper do not spawn until they are nearly a year of age. In almost all marine bivalves, the eggs and sperm are simply discharged into the water through the excurrent siphon and fertilization of the egg takes place in the water. Each bivalve spawns several times during a season, as only a portion of

the sex products or gametes ripen at any one time. Residual gametes which remain at the conclusion of the spawning season are later resorbed by the clam. Ripe and spawning bivalves are fat and succulent, almost entirely filling the inside of the valves.

Eggs of bivalves are round and very small. A single Pismo clam egg measures about 1/350 of an inch in diameter, one from the Japanese littleneck is about 1/430, while one from an Eastern oyster is but 1/500 of an inch. A single large Eastern oyster may spawn 100 million eggs in one season, a bay mussel 25 million, a Pismo clam 15 to 20 million and a northern razor clam 6 to 10 million.

The spawning season varies considerably for different species and, in fact, even for the same species at different geographic localities, presumably as a result of water temperature. In general, it is believed that first spawning is in the spring, when water temperatures warm up a few degrees, and is concluded during the fall months each year.

### LARVAE

The fertilized egg develops into a microscopic free-swimming larva which is known as a veliger. These veligers hatch from fertilized eggs at any time from a few hours to a few days after the eggs are spawned. They move about by means of short hair-like processes or cilia, which move enough to propel them through the water at relatively slow speeds. Very little is known about this larval period for any of the species discussed in this paper. The free-swimming period is thought to last from a few days to several weeks, depending upon the species, temperature, and other factors. The Japanese littleneck was found to have a complete shell and adductor muscles about 22 hours after fertilization of the egg. However, specific characteristics such as radiating ribs did not appear until 27 days had elapsed.

Many young clams, upon setting, dig into the bottom a fraction of an inch and anchor themselves by means of a fine thread or byssus. The byssus usually has a number of sand grains attached to its distal end which improves the anchorage of the young clam in a shifting bottom. In many species the byssus degenerates within a few months as the clam becomes more able to care for itself. Mussels retain the byssus throughout life, as do the jingles.

## ECOLOGICAL RELATIONSHIPS

The number of different plants or animals which depend upon the bivalves for optimum living conditions is not known, nor are the dependencies of many bivalves to other forms in their environment thoroughly understood in all cases.

Perhaps one of the most interesting relationships is that of the jellyfish-like animal or hydroid, *Clytia bakeri,* to bean clams and Pismo clams. Colonies of these hydroids growing on the siphonal end of living bean and Pismo clams have much the appearance of a tuft of hair sticking from the sand. On one occasion a small crab was found living in the hydroid colony on a bean clam. Within the valves of the bean clam a small and delicate crab was found living commensally, and microscopic

examination of the tissues of the clam revealed several cysts which contained numerous larvae of one of the flukes (a parasitic worm). Here were five different organisms, three of which were directly and the fourth indirectly, dependent upon the bean clam.

Small commensal crabs have been found living in nearly all of the species of bivalves discussed in this paper. The bivalve affords the crab protection, food, and good living conditions, but how or if the crab repays this hospitality is not known. A nemertean worm, *Malacobdella grossa,* has been found commensally associated with the white sandclam and the northern razor clam. A copepod, *Modioicola gracilis,* has been found within the mantle cavity of bay mussels; larval tapeworms are often heavily encysted in the foot of the gaper and larval trematodes or flukes are to be found encysted in the foot or gonads of the bean clam, Pismo clam, littlenecks and many others.

The enemies of bivalves are numerous and varied. Gulls, sharks, rays, fishes, starfish, flesh-eating snails, and crabs are among the best known.

Many fishes bite off the extended siphons of clams, some feeding almost exclusively on these morsels. Other fishes feed on whole clams which they grub or root out of the bottom. Rays have been known practically to denude a clam bed by using their "wings" to set up a suction which pulls the clam from the sand or mud. Gulls may either pick up small clams at or near the surface or carry large clams aloft, dropping and cracking them on the hard packed sand. Several species of crabs crack clams in their front pincers and feed upon the meat. There are a number of flesh-eating snails which feed particularly upon bivalves. These snails attach themselves to the shell of their victim, drill a small hole through the shell with a rasplike tongue, and then proceed to feed upon the clam through the hole they have drilled. Starfish feed almost exclusively on bivalves and particularly on mussels. These clamp their arms around a living mussel and by exerting tremendous pressure pull the two valves apart, exposing the meat. The starfish then turns its stomach inside out, folding it around the meat of the mussel, which is soon digested.

## ECONOMIC IMPORTANCE

### GENERAL

Not all of the bivalves are beneficial to man. Among those which are definitely harmful is the teredo or shipworm, a close relative to the piddocks, which annually causes millions of dollars of damage to wooden structures exposed to sea water. This bivalve, which lives on and in wood, has caused piers and docks to fall, bridges to be abandoned, and ships to sink. In addition to the damage it does, millions of dollars are spent each year in attempts to prevent or discourage its activities.

Mussels also cause a considerable amount of harm each year, but could not, perhaps, be considered destructive, except to health. The greatest expense incurred by man from mussels results from their growth in great masses and clumps, fouling intake pipes of steam and other industrial plants and fouling ship bottoms, necessitating drydocking for removal.

On the beneficial side bivalves are of greatest importance to man for their food value. Of secondary importance are such items as bait for sportfishing, button manufacturing, pearl culture, shell collecting, and souvenirs. Most of the mussels and clams are used by sportfishermen for bait along the entire coast of California. Some, such as the jackknife and Pismo clam and the California sea mussel, are more important than the others for bait. Though pearls occur in many of our bivalves, none of those discussed in this paper, except the California sea mussel and the giant horsemussel, have been known to produce pearls with any luster. For the most part, natural pearls from California bivalves are dull in color and texture and of no commercial value.

The chemical composition of the meat of bivalves is not constant, but varies over a wide range depending upon the quality of the bivalve, the collecting locality, the concentration of salts in the sea water, and the season. The amount of mineral salts varies from about 0.5 to 2.76 percent and consists primarily of sodium chloride (ordinary table salt) but contains also almost every chemcal element present in sea water. Qualitative spectrographic analyses have indicated the presence of over 20 minerals in the meat of bivalves.

It has been estimated that six eastern oysters (weighing approximately three and one-half ounces) served raw will supply more than man's daily requirement of iron and copper, about one-half of the iodine needed, and about one-tenth of the necessary protein, calcium, phosphorus, vitamin A, thiamine, riboflavin, and nicotinic acid. For several species of clams and oysters, portions approximately three and one-half ounces in weight will supply 60 calories of food energy.

Recently published information giving vitamin content of the softshell clam and the quahog indicates that these two species are among the best known natural sources of vitamin $B_{12}$, furnishing 6.0 to 9.7 micrograms of $B_{12}$ per gram of dry clam. Canned clams showed a lower $B_{12}$ content than raw clams and canned minced clams were extremely low in vitamin $B_{12}$.

## MUSSEL POISONING

Serious or fatal cases of poisoning from eating mussels have long been known from Europe and the west coast of North America. In late July or early August, 1799, over a hundred Aleut hunters, who had been in the company of Baranov, died within a few hours after eating black mussels which they gathered along the coast of Alaska between Kodiak and Sitka. The strait where this party camped has since been known as Peril Strait.

In the nine-year period from 1927 to 1936, 243 cases of paralytic shellfish poisoning of which 16 were fatal, were reported from the Pacific Coast. This type of poisoning, though long known to occur, has been partially explained only within the last two decades. Cases of poisoning occur almost entirely during June to September and chiefly in July and August. They result largely from the eating of mussels but also from clams taken on the open coast. Although illness may result from eating spoiled shellfish, the nature of this illness is very different and the danger far less than from the typical mussel or paralytic poisoning. After a search extending over several years, the poison was traced to a

microscopic animal, the dinoflagellate *Gonyaulax*. This organism becomes very abundant in the ocean during the summer months and it is during these periods of abundance that mussels feeding upon it become extremely toxic. A complex method of biological assay was devised by Drs. Herman Sommer and Karl F. Meyer, University of California, for the California State Department of Health. The California State Department of Health follows the condition of the bivalves carefully throughout the year and when they become dangerous, quarantine notices are posted in conspicuous places along the beaches of the State.

The poison is one of the most virulent known. Its action is rapid, symptoms appear in 15 minutes to five hours and pass their peak, in persons who recover, in about 24 hours. One of the first symptoms is tingling (pins and needles) of the lips, finger tips or toes. This may be followed by paralysis of the hands, feet, neck muscles and muscles of respiration. Death usually occurs from failure of respiration.

## CLAMMING METHODS AND GEAR

In order to be a successful clammer one should go to the right locality, know how to find what is there and have the proper tools to dig what one finds.

There are many ways to locate bivalves at a clam digging locality. If bay or sea mussels are desired, one must search such typical habitats as exposed rocks, pilings, floats, etc. Pismo clams must be probed for, or perhaps one can find tufts of hydroids which grow on Pismo clam shells sticking from the sand; these hydroid colonies also aid in locating bean clams. Northern razor clams are located by pounding on the sand and spotting the hole the clam leaves at the surface when disturbed by the vibrations of the pounding. On mud flats, as the tide comes in, one can locate gapers and geoducks by the squirting they do. Littlenecks and chiones are mostly found by probing near the surface of the mud flats or under rocks. The one method most difficult to describe and yet the only practical way to locate many of our bivalves is to look for the typical siphon holes left at the surface of the sand or mud. Once an individual is able to recognize a species by the shape and size of the siphon hole a new era of clam digging begins for him. These holes, many sizes and shapes, single or double, are distinct for each species and many a shrimp, worm or crab is dug before the beginner is certain enough of his judgment to bypass the holes made by others than clams.

Nearly any implement used in the capture of bivalves is called a "clam gun." It may be a shovel, a rake, a hook or a dart, but when employed to obtain clams, it is a clam gun. Perhaps the most important item of all is a long-handled shovel which can be used for nearly all of the burrowing clams but is indispensable for gapers and geoducks. In digging these latter two species, where one must go quite deep, a piece of stove pipe or a bucket open at both ends is pushed down around the siphon to keep the hole from caving. For Pismo clams, where probing is necessary, a six-tined potato fork is most efficient, though in some localities a recurved hay fork, which can be dragged through the sand, is preferred. Jackknife clams are gathered with an arrow-shaped dart on the end of a long, stiff wire. The dart is pushed into the mud parallel

to the two siphon holes and when the clam has been speared, a half turn on the wire and a lift to the surface will usually bring up the clam. In some areas where the mud is soft, a heavy rod up to three feet in length, with a handle at one end and a two-inch-long right angle hook at the other, is used to obtain Washington clams. Here the siphon hole is located at the surface, the hook end of the rod is pushed down the siphon hole until the clam is felt, the hook is then passed under the clam and a series of upward bumps will usually bring it to the suface. A garden trowel or hand cultivator is almost a "must" if one is digging littleneck clams and chiones. A long-handled screwdriver saves lots of time when prying mussels off rocks, floats, etc. A grappling hook on a long rope works equally well from a pier or dock to remove mussels from pilings. A tire iron or long-handled screwdriver is also necessary to remove rock scallops, while a coat hanger with trailing hooks or a piece of chicken wire dragged through a likely pool or channel will often capture speckled scallops. A cold chisel and sledge hammer is invaluable for chipping chamas off the rocks or breaking up small pieces of rocks in which there are piddocks. For breaking up the larger boulders in which piddocks are found, mattocks, picks, gads, etc. are very handy.

## PREPARATION

### GENERAL

One of the biggest problems facing clammers after a successful digging expedition is how to clean and prepare their bag. Many people believe that if salt water bivalves are placed in a tub of fresh water, to which some cornmeal has been added, the clams will purge themselves of sand, feed on the cornmeal and be ready for the frying pan when removed. This is not true; placing salt water clams in fresh water only causes them to close tightly and eventually they will die without cleansing themselves of as much as a grain of sand. If placed in fresh sea water, they will purge themselves in time but the sea water must be changed often. Such clams as the bent-nose must be kept in clean sea water away from mud for three or four days before they are fit to eat and to the writer's knowledge there is no other satisfactory method to clean the mud from this species. For most of the other clams a very practical and easy method to remove sand is to rinse the meat under a fast running faucet.

The easiest method to clean gapers, geoducks, some of the piddocks and other bivalves which have a heavy epidermis over their siphons and other parts is to hold them momentarily under the hot water tap for then the "skin" loosens and pulls off.

Bivalves with thick shells which close tightly may, if kept cool and moist, be held out of the water for periods of five or six days before opening. Those with thin shells or which gape somewhat at their edges will seldom keep for more than a day or two out of the water. Pismo clams have been kept in a wet sack for seven days and were still alive at the end of that period; a quahog lived for nearly 30 days out of the water. The northern razor clam will usually not survive for much more

than a day, nor will the geoduck, scallops and several others. Most bivalves will live for periods up to a week if kept in sea water which is changed about twice a day; they should not, however, be held in water in galvanized containers, as the electrolysis which results will inevitably kill the clams in a very short time.

## OPENING

Opening those bivalves which have relatively thick shells and close tightly is always a problem. The most popular implement for opening these alive is a stiff-bladed knife. If the clam is allowed to lie undisturbed for a short period of time, it will usually open its shell a fraction of an inch and by some fast maneuvering with a knife one of the adductor muscles can be sliced in two. Once this one muscle is severed, the clam is not able to close tightly and the other muscle can then be cut allowing the shell to gape freely. At this point, the clam can be placed under a fast running faucet and all sand washed out. At no time before cutting the muscles should an attempt be made to rinse in fresh water as the clam will shut tightly the second the fresh water strikes it. All opening should be done in a flat, shallow pan so that the juices which run out can be saved and used in broth or chowder.

An alternative method which works well with practice is to force a knife blade between the two valves by sheer strength, cut one of the adductor muscles and proceed from there as outlined above. This is probably the most dangerous method as slips may mean cut fingers. For clams with thin shells and those which gape at either or both ends, this is probably the simplest way to open them alive. It should be remembered that scallops and oysters have but a single adductor muscle.

If it is not necessary to have the clam alive and yet the meat is desired raw, the most practical method is to place the bivalve in the freezing compartment of a refrigerator for an hour or so. As soon as the clam freezes, the muscles relax and the hinge ligament forces the shell open. A knife can be used on these gaping clams without danger of its slipping.

Finally, and by far the most popular method, is steaming. The clams are placed in a large container which has some water in the bottom and covered with a tight fitting lid. Placed over heat, the clams are steamed open and the meat can be readily removed. The juice, from which the sand can be strained, should be saved for future use.

## REMOVAL FROM SHELL

After a clam has been steamed its valves stand open and the meat usually will fall out or can be picked out. Sometimes the meat sticks to the shell at the attachment of the two adductor muscles. This can be scraped free with either a thin-bladed kitchen knife or with the thumbnail.

If a clam has been opened raw by severing the adductor muscles, a thin-bladed knife should be inserted between the mantle and the inside

of the shell. With this, the mantle is easily lifted away from the shell and the meat is then held in the shell only by the adductor muscles. When these muscles are sliced through next to the shell the meat usually falls out without further manipulation.

### TRIMMING

Many people do not discard any part of the clam before using it as food and if a person is not a finicky eater, there is nothing wrong with this method, particularly for mussels, oysters and those clams less than two inches in diameter. For those who wish to enjoy their clams to the utmost, or wish to try them in other ways than just chowder, a certain amount of trimming can be done. For the large hard-shell clams such as the Pismo and Washington, the buttons (adductor muscles) should be removed. In most scallops the adductor muscle is the only part which is saved and eaten by many people, while others use the entire animal. After removal of the buttons from the large clams, the siphons, mantle, and gills should be trimmed off, leaving only the foot. The dark mass of liver can be removed with the thumbnail and discarded and the hard, digging edge of the foot should be removed. Upon completion of trimming, one should have left a section of the soft base of the foot about the diameter of a silver dollar which can be sliced lengthwise and used for frying. The buttons are excellent in cocktails and the remaining trimmings can be ground for chowder, croquettes, dressing, etc.

Those clams with long, meaty necks such as the geoduck, gaper, wart-necked, rough and mud piddocks present problems all their own. Removal of the dark outer covering (the epidermis) exposes a rich white meat which is of excellent flavor. This is usually sliced into frying size, pounded as if it were abalone steak, rolled in egg batter and cracker meal and fried.

### USE AS FOOD

All of the bivalves discussed in this paper are edible and of good flavor. The flesh of most is light in color, predominantly cream, buff or whitish. The California sea-mussel is reddish orange, the bay mussel somewhat lighter and the ribbed horsemussel a lemon yellow. The gonads of many of the scallops are bright orange or red, but in none of these is the flesh unpalatable.

## MANAGEMENT

### INTRODUCTIONS

With the exception of the Eastern and giant Pacific oysters, none of the several exotic bivalves now found in the State was a planned introduction. The soft-shell clam and ribbed horsemussel were accidental introductions, having been brought into the State with oyster spat from the

east coast. The quahog may have been introduced the same way or may have resulted from spawning of quahogs shipped alive to California and held in live cars or receivers by various fish dealers. The Japanese littleneck may have come in accidentally with giant Pacific oyster spat or could have been brought in by some Japanese and dumped into San Francisco Bay. Finally, the bay mussel was probably introduced unknowingly by the early sailing boats from Europe, the bottoms of which were usually fouled with growths of mussels, barnacles and the like. They could have gotten their start on the California coast by spawn liberated into the water by the mussels growing on the ship bottoms or by clusters having been scraped off into our bays or other anchorages from whence they reproduced.

## TRANSPLANTS

In numerous instances, Pismo clams were planted on various beaches between Washington and Baja California where extensive populations of this much sought after species did not exist. To the writer's knowledge none of these transplants were successful. Transplanting of native species has been generally frowned upon because it is felt to be a definite waste of effort. If conditions on a particular beach were satisfactory for successful growing of a certain species, it would most assuredly have become well established at some time during the 25,000 years or so that most of our native bivalves have been in existence.

On the other hand, the chances of exotic species becoming established are often quite good and many of these have been found to be highly desirable additions to our fauna. As a result of harbor dredging, heavy digging pressure, pollution, etc., many native species are disappearing from Southern California bays. To help remedy this situation introduction of the Japanese littleneck is contemplated within the next few years.

## LAWS

Certain of the more important edible species of bivalves are protected by laws. These include any or all of the following: bag limits, size limits, closed seasons, closed areas, restrictions as to hours during which clams may be dug, and regulations regarding return of undersized clams. The aim of these laws is to prevent overexploitation and to maintain a group of breeding animals that will insure a future supply. A valid California angling license is required for digging or capture of any bivalve. For those species which are sold, a commercial license must be possessed by the seller.

Since the regulations on a particular species are subject to change from one year to the next, those in effect during one season should not be taken as the final word during the next succeeding season. To obtain up-to-date information one should get in touch with the nearest office or representative of the California Department of Fish and Game.

## GLOSSARY OF TECHNICAL TERMS

Adductor muscle scars—Depressions, usually circular or ovate in outline on the interior of the shell which mark the attachment area of the muscles which the bivalve uses to close its shells. There may be one or two in each shell.

Anterior end—The head end, which in bivalves is the opposite end from which the siphons protrude. If no siphons are present (scallops, etc.), it is the end in which the foot is found.

Byssus—A tuft of long tough filaments which is secreted by a gland in the foot of some bivalves and by which the bivalves attach themselves to rocks or other solid objects.

Cilia—Hairlike processes capable of a vibratory or lashing movement, found on many cells and along the gills of bivalves.

Commensal—An organism, not truly parasitic, which lives in, with, or on another, partaking, usually, of the same food.

Crenulate—Having the margin minutely notched or regularly indented.

Epidermis—the fibrous outer covering of the shell or animal; synonymous with periostracum.

Escutcheon—A circumscribed or depressed area along the dorsal margin posterior to the beaks.

Falcate—Hooked or curved like a sickle.

Foot—A fleshy organ of locomotion, usually along the midline of the bivalve, which may be especially adapted for burrowing, creeping, swimming, etc.

Hermaphrodite—An organism having both male and female reproductive organs functional in the same individual.

Lamellae—Thin, leaflike plates or foliations which make up part or all of the external sculpture on some bivalves.

Left valve—The valve to the left when the specimen is held with the hinge area up and the pallial sinus or siphons pointing toward the observer.

Lunule—A heart-shaped, circumscribed or depressed area anterior to the beaks.

Mantle—The pair of lobes (outer layer of tissue) of the body wall which lines the shell and bears the shell-secreting glands.

Mantle cavity—The space between the mantle and the body of the bivalve in which are found the respiratory organs.

Nacreous—The pearly or iridescent inner layer of shell.

Pallial line—A linear impression connecting the adductor muscle scars, marking the attachment of the mantle margin to the shell.

Pallial sinus—A curved indentation in the pallial line, near the posterior end of the shell, which marks the attachment of the siphon retractor muscle.

Palps—Four leaflike, fleshy appendages, which surround the mouth and conduct food into it.
Periostracum—The thin, outermost shell layer of many bivalves which protects the calcareous parts of the shell from damage by erosion.
Radial sculpture—Usually lines on the outside of the shell which extend from the umbones or beaks toward the ventral margin of the shell.
Right valve—The valve to the right when the specimen is held with the hinge up and the pallial sinus or siphons pointing toward the observer.
Siphons—Tubular structures at the posterior end of the bivalve through which water enters and leaves the animal.
Substrate—The underlying substance (rock, wood, etc.) to which sessile bivalves are attached.
Umbo—A lateral prominence or beak just above the hinge on the shell of a bivalve. It is the first formed part of a bivalve.
Valve—One of the two calcareous pieces which together make up the shell of a bivalve.

## A KEY TO SOME MARINE BIVALVES OF CALIFORNIA

Of the more than 400 species of bivalves known from the coast of California, only 60 are considered of economic importance. The following key will serve to aid in identifying those forms which are treated in the present paper. To use this key successfully one must have the entire bivalve in his possession and know some of the habits and habitats of the species in question. The key is made up of double sets of statements and each such set is numbered serially in the left hand column. If the statement regarding the bivalve in question is correct, either a scientific name or a number is given at the end of the statement. If a scientific name appears the bivalve has been identified; if a number appears one must find that number in the left hand column and proceed reading statements. The second column on the left contains numbers in parentheses. These numbers refer to the numbered statement which directed the user to the new number (i.e. the arrangement "10 (1)" indicates that the person using the key is at statement number 10 and that he arrived there directly from statement number 1). To have identified a native oyster, *Ostrea lurida*, by the key, a person would have read statements 1, 2, 4, 5 and 6 in that order. To identify a California sea-mussel one would progress through statements 1, 10 and 12. To further facilitate use of the key, line drawings illustrating various anatomical structures have been included.

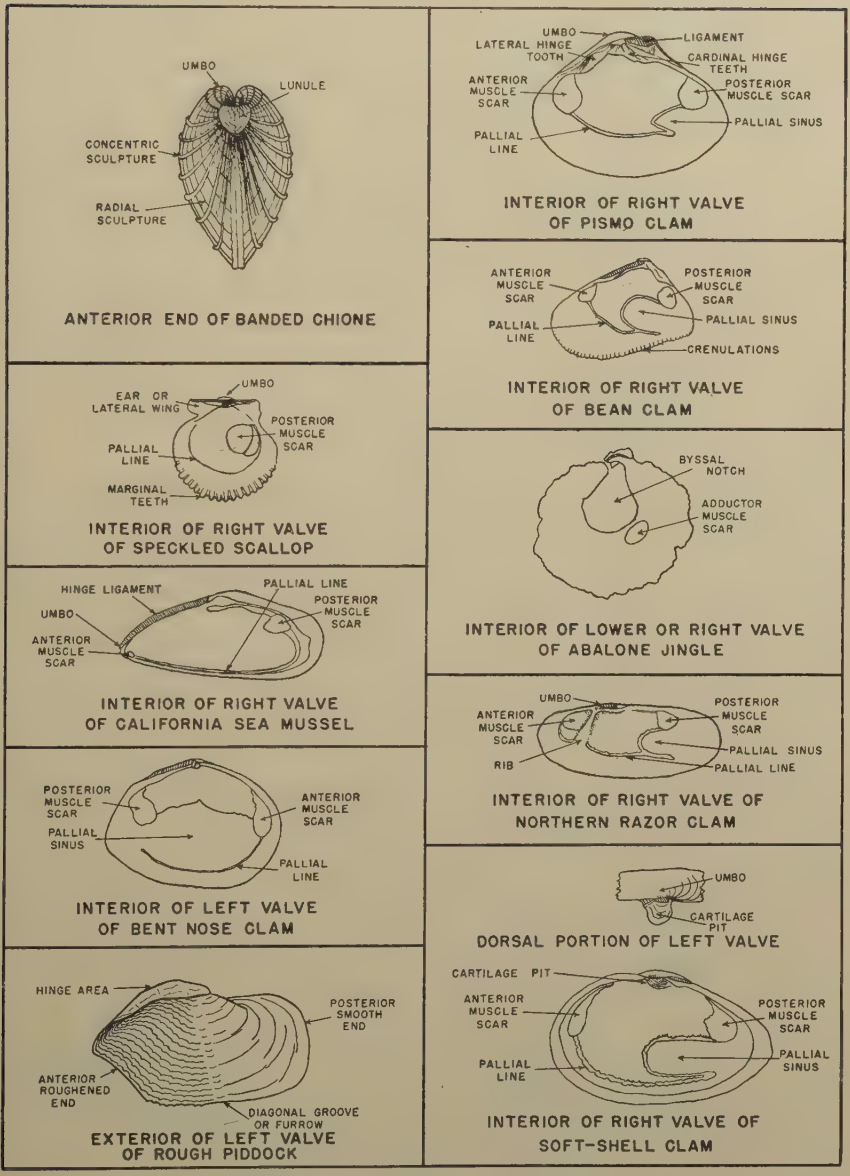


FIGURE 3. Illustrated terminology

1 Only one adductor muscle (posterior) present; mantle edges not fused, hence no siphon or pallial sinus; adults either rigidly attached, usually by cementation, or entirely free and capable of swimming actively; always lying on one side ---------- 2

Two adductor muscles present; adult usually free, moving by a muscular foot or burrowing, or attached by a flexible byssus, rarely attached by cementation (*Chama* or *Pseudochama*) or capable of actual swimming ---------- 10

2 (1) Valves unlike, the right with a deep notch (apparently a hole) for the passage of a byssus by which the animal is attached.....Jingles 3

Valves, whether similar or unlike without byssal notch..... 4

3 (2) Left valve with two muscle scars (posterior adductor and byssal muscles); shell light but not delicate, surface of shell roughened but not translucent.....Abalone jingle, *Pododesmus cepio* (page 45)

Left valve with three muscle scars (posterior adductor and two byssal muscles); shell very delicate, smooth surfaced and usually translucent; rarely taken between tides.....Pearly jingle, *Anomia peruviana* (page 46)

4 (2) Shell irregular, without radiating ribs or lateral projections on either side of the umbo; permanently attached by left valve; mantle without eyes; flesh white or tinged with greenish; found in colonies or masses Oysters 5

Shell regular, with radiating ribs and lateral projections or wings (ears) on either side of the umbo; free for at least part of adult life; margin of mantle with numerous eyes; flesh often tinged with orange or red; not in colonies or masses.....Scallops 7

5 (4) Muscle attachment scars purplish-black; shell elongate, almost triangular, broadest end opposite umbo Eastern oyster, *Crassostrea virginica* (page 40)

Muscle attachment scars never black..... 6

6 (5) Shell small, irregular, usually nearly round or elliptical in outline, both valves generally flat.....Native oyster, *Ostrea lurida* (page 38)

Shell very heavy, elongate and strap like, attains extremely large size; upper valve usually flat (anterior to posterior margin), lower valve deeply cupped.....Giant Pacific oyster, *Crassostrea gigas* (page 39)

7 (4) Shell free and regular in shape for entire life; interior of hinge area not purplish; shell light; capable of active swimming..... 8

Shell free and regular for only early part of life, later attached by right valve, which retains pattern of young free shell; interior of hinge area purplish; shell heavy and thick Rock scallop, *Hinnites multirugosus* (page 41)

8 (7) Both valves hollow or convexly rounded in form..... 9

Left valve flat, reddish in color; right valve convexly rounded, orange in color; radiating ribs even, distinct, almost square at angles San Diego scallop, *Pecten diegensis* (page 43)

9 (8) Margin of shell not deeply scalloped, usually rather smooth; radiating ribs gently rounded; shells large and in California usually from deep water; shells much flattened Weathervane scallop, *Platinopecten caurinus* (page 44)

Margin of shell deeply scalloped; radiating ribs sharply rounded, distinct even on inside of shell; color varied, usually with dark mottling on all or part of exterior; shells strongly convex Speckled scallop, *Plagioctenium circularis aequisulcatum* (page 42)

10 (1) Posterior adductor scar large, anterior small; umbo near anterior end of shell; mantle edges fused only at one point, forming an exhalent siphonal aperture; no pallial sinus; adults attached to firm objects or anchored in mud by byssus, never lying on one side; never moving about when adult; shells brown or shiny black.....Mussels 11

Adductor muscle scars equal or nearly so; umbo not at end of valve (except Solen); mantle edges fused in at least two places forming two siphonal apertures, which are usually prolonged into siphonal tubes; usually capable of moving about by means of the foot; most species capable of burrowing to some extent and habitually doing so; color of shell various, never black.....True clams 18

11 (10) Anterior end of shell tapering to a point; umbos terminal; shells not bearded, periostracum black or sometimes brown, interior of shell blue-black; attached, often in "beds" to rocks or piles ..... 12

Anterior end of shell not tapering to a point but rounded; umbos near but separate from anterior end; shells bearded or otherwise roughened; periostracum brown; interior of shell not blue-black (except in *Volsella demissa*); usually solitary; burrowing in mud, gravel or rock ..... 13

12 (11) Adult with prominent growth lines and usually a few radiating lines to extreme posterior margin of valve; in beds on rocks exposed to surf
California sea-mussel, *Mytilus californianus* (page 52)

Adult smooth; on piles, rocks, ships, etc., usually not exposed to surf
Bay mussel, *Mytilus edulis* (page 53)

13 (11) General form not cylindrical, anterior end not globular ..... 14

General form cylindrical, anterior end globular
Rockboring mussel, *Lithophaga plumula kelseyi* (page 54)

14 (13) Partially buried in mud or sand; usually posterior portion of shell bearded; no transverse wrinkles on shells ..... Horsemussels 15

In burrows in hard rock; attached by byssus; skin with many transverse wrinkles ..... Pea-pod borer, *Botula falcata* (page 51)

15 (14) Shell with radiating ribs, not bearded; periostracum dark brown; mud flats in "beds" at bases of marsh reeds; flesh usually a bright yellow.
Ribbed horsemussel, *Volsella demissa* (page 50)

Shell with no raised ridges, bearded; periostracum light brown; usually solitary in mud ..... 16

16 (15) Umbo near, but not at, anterior end; slender, width about $\frac{1}{3}$ length ..... 17

Umbo at but separate from, anterior end; ligament at slight angle to ventral margin of valve; not slender, width usually about $\frac{1}{2}$ length
Fat horsemussel, *Volsella capax* (page 47)

17 (16) Ventral edge arched; posterior end broad
Giant horsemussel, *Volsella flabellata* (page 49)

Ventral edge straight roughly paralleling dorsal edge
Straight horsemussel, *Volsella recta* (page 48)

18 (10) Adult attached by cementation; valves unlike, very irregular; depth (measured from the center of the free to the center of the attached valve) often greater than any other dimension; muscle scars strikingly large ..... 19

Adult not attached by cementation; valves not irregular; thickness never the greatest dimension; muscle scars not strikingly large ..... 20

19 (18) Shell attached by the left valve (the ligament extends posteriorly from the umbo; if the umbo is held uppermost with the ligament extending toward you, the right and left valves will correspond to your right and left hands) ..... Agate chama, *Chama pellucida* (page 58)

Shell attached by the right valve
California reversed chama, *Pseudochama exogyra* (page 59)

20 (18) Valve margins closing completely, or at least with no marked gaping; siphons completely retractile, not visible in the closed shell ..... 21

Valve margins when closed gaping at points where siphons or foot or both are protruded; siphons not completely retractile, visible in the closed shell ..... 46

21 (20) Valves symetrical, thick and strong; siphons usually united and short; if burrowing, not lying on one side ..... 22

Valves asymmetrical, especially at the siphonate (posterior) end, usually thin and weak, particularly at the margins (least marked in *Semele* and *Tellina*); siphons separate, slender and very long; deeply burrowing in sand or mud where they lie on one side ..... 41

22 (21) Siphons extremely short, not projecting beyond shell when extended; no pallial sinus; not burrowing deeply ..... True cockles 23

Siphons short or moderate; pallial sinus present; burrowing more or less deeply ..... 25

23 (22) Radiating ribs conspicuous and sharply raised above surface ..... 24

Ribs faint and gently rounded
Smooth giant cockle, *Laevicardium elatum* (page 56)

24 (23) Ribs roughened ..... Basket cockle, *Clinocardium nuttalli* (page 57)

Ribs with rows of spines
Spiny giant cockle, *Trachycardium quadragenarium* (page 55)

25 (22) Valves crenulate or finely toothed on inner surface of margins, teeth interlocking in closed shell ..... 26

Valves smooth at margins, sometimes roughened but without regular crenulations ..... 28

26 (25) Size small; siphons separate, fairly long; pallial sinus reaching about half way to anterior muscle scar; no lunule ..... 27

Size medium to large; siphons extremely short; pallial sinus reaching about one-fourth of distance to anterior muscle scar; lunule present
Quahog, *Venus mercenaria* (page 61)

27 (26) Umbo central; shell buff colored, covered with smooth, hard periostracum ..... Wedge clam, *Donax californicus* (page 85)

Umbo much nearer posterior end; shells multi-colored, covered with thin periostracum ..... Bean clam, *Donax gouldi* (page 84)

28 (25) Pallial sinus deep, reaching more than half way to anterior muscle scar ..... 29

Pallial sinus shallow, reaching less than half way to anterior muscle scar ..... 33

29 (28) Valves with radiating ribs; siphons united for most of their lengths; periostracum thin, inconspicuous ..... Littleneck clams 31

Valves without radiating ribs; siphons separate for entire length; conspicuous periostracum covering most of valves ..... 30

30 (29) Valve oval (about one and one-half times as long as wide); umbos about central ..... Sunset clam, *Gari californica* (page 81)

Valve elongate (about twice as long as wide); umbos much nearer anterior end ..... Deep water gari, *Gari edentula* (page 80)

31 (29) Valves elongate; ribs small but distinct, concentric ridges more prominent than ribs; pallial sinus reaching $\frac{2}{3}$ of distance to anterior muscle scar; valve margin smooth
Thin-shelled littleneck, *Protothaca tenerrima* (page 65)

Valves rounded in outline; ribs prominent; valve margins roughened; pallial sinus reaching over $\frac{1}{2}$ of distance to anterior muscle scar ..... 32

32 (31) Radiating ribs numerous, fine; concentric ridges faint to lacking; color pattern on outer surface of shell exteremely variable
Common littleneck, *Protothaca staminea* (page 66)

Radiating ribs and concentric ridges prominent forming a sharp, coarse network; shell often over three inches in diameter
Rough-sided littleneck, *Protothaca laciniata* (page 68)

33 (28) Ligament external; valves heavy with moderate or thick edges ..... 34

Ligament internal; valves lighter, thin and sharp at edges; size moderate or large; pallial sinus reaching $\frac{1}{3}$ to $\frac{1}{2}$ distance to anterior muscle scar ..... 39

34 (33) Valves smooth, very heavy, with conspicuously glossy, persistent periostracum; pallial sinus reaching less than $\frac{1}{3}$ of the distance to the anterior muscle scar; found in sand on open beaches
Pismo clam, *Tivela stultorum* (page 60)

Valves not smooth, marked with concentric ridges or radiating ribs and sometimes both ..... 35

35 (34) No radiating ribs, concentric ridges low, rounded, occasionally dividing into two; covered with a heavy glossy, persistent periostracum; pallial sinus reaching about half way to anterior muscle scar; valve margin smooth; shell white ..... White amiantis, *Amiantis callosa* (page 62)

Radiating ribs present though often not so prominent as concentric ridges; pallial sinus shallow; periostracum thin, grey, easily detached 36

36 (35) External ligament raised, well above shell on either side of its base; pallial sinus deeper than diameter of posterior muscle scar, reaching somewhat less than half way to anterior muscle scar; shell often vari-colored——Japanese littleneck, *Tapes semidecussata* (page 67)

External ligament not raised, shell on either side of its base usually higher than ligament; pallial sinus shallow, not deeper than diameter of posterior muscle scar; shell never vari-colored, usually grey or buff 37

37 (36) No distinct lunule nor escutcheon; ribs more prominent than concentric ridges in posterior third of valve; pallial sinus forming angle
Smooth chione, *Chione fluctifraga* (page 69)

Distinct lunule and escutcheon present; concentric ridges usually more prominent than ribs in all parts of valve; pallial sinus rounded—— 38

38 (37) Numerous thin concentric ridges; ribs everywhere small and inconspicuous——Wavy chione, *Chione undatella* (page 70)

Concentric ridges heavier and less numerous; ribs at posterior end more distinct than elsewhere but not more conspicuous than ridges
Banded chione, *Chione californiensis* (page 71)

39 (33) Pallial sinus united with pallial line; anterior slope of valve not concave; a ridge of epidermis along siphonate end
California mactra, *Mactra californica* (page 86)

Pallial sinus not united with pallial line; interior of valve not markedly roughened —— 40

40 (39) Anterior slope of valve distinctly concave
Hemphill's dish clam, *Spisula hemphilli* (page 88)

Anterior slope of valve not concave
Narrow dish clam, *Spisula catilliformis* (page 87)

41 (21) Ligament wholly external; pallial sinus united with pallial line; valves generally thin —— 42

Ligament in part external but with a larger internal part (cartilage); pallial sinus not united with pallial line; valve round in outline, fairly heavy, tinged with lavender at margins
Clipped semele, *Semele decisa* (page 83)

42 (41) Valve elongate (about twice as long as wide); periostracum conspicuous; shell not conspicuously thin; whitish with fine but very regular growth lines, siphonate end bent to right
Bodega tellen, *Tellina bodegensis* (page 73)

Valve oval or round in outline; valve conspicuously thin; growth lines usually faint, always more or less irregular—— 43

43 (42) Shell whitish without conspicuous periostracum—— 44

Shell blue or purplish with conspicuous glossy reddish brown periostracum; right valve much flatter than left; found in coarse sand or gravel
Purple clam, *Sanguinolaria nuttalli* (page 82)

44 (43) Ligament depressed so as not to be visible from the side; siphonate end of shell not produced; valves deeply arched
Yellow apolymetis, *Apolymetis biangulata* (page 72)

Ligament not depressed, hence visible from the side; siphonate end of shell more or less produced; valves not deeply arched—— 45

45 (44) Siphonate end of shell produced and bent to right; valves about equally arched; pallial sinus in left valve reaching anterior muscle scar; found in protected mud or muddy sand
Bent-nose clam, *Macoma nasuta* (page 74)

Siphonate end of shell slightly produced, not bent; left valve much flatter than right; pallial sinus not reaching anterior muscle scar in either valve; found deep in loose exposed sand
White sand clam, *Macoma secta* (page 75)

46 (20) With a furrow dividing the valve into anterior (roughened) and posterior (smooth) areas—— 57

Without a furrow dividing the valve into anterior and posterior areas—— 47

47 (46) An accessory dorsal plate covering ligament
Mud piddock, *Barnea pacifica* (page 94)
No accessory dorsal plate ---- 48

48 (47) Ligament external ---- 49
Ligament internal ---- 55

49 (48) Shell not markedly elongate (length less than 3 times breadth); animal not moving freely up and down in permanent burrow ---- 50
Shell strikingly elongate (length 3 or more times the breadth), with dorsal and ventral margins parallel or nearly so, gaping about equally at both ends; animal moving freely up and down a permanent burrow ---- 53

50 (49) Shell very thin and fragile, over twice as long as wide and gaping about equally at either end; conspicuous, glossy periostracum; a marked rib on the interior of each valve extending from the umbo toward the free margin; found in clear sand on open beaches
Northern razor clam, *Siliqua patula* (page 78)
Shell not exceptionally thin nor gaping at anterior end to accommodate foot; periostracum not conspicuous, no internal rib; not found on open beaches ---- 51

51 (50) Valve margins not meeting at any point in living animal, mantle not completely retractile; valves gaping at posterior (siphonate) end to accommodate siphons; pallial sinus small, not reaching over $\frac{1}{3}$ of distance to anterior muscle scar; siphons extremely long and large, covered with thick dark epidermis, but without terminal plates.
Geoduck, *Panope generosa* (page 92)
Shell gaping moderately, mantle completely retractile; pallial sinus deep, reaching $\frac{1}{2}$ to $\frac{2}{3}$ of the distance to the anterior muscle scar; siphons long, without heavy epidermis ---- Washington clams 52

52 (51) Concentric ridges heavy, widely spaced; interior of shell at siphonal end marked with purple
Common Washington clam, *Saxidomus nuttalli* (page 64)
Concentric ridges thin, finely spaced; interior of shell at siphonal end never marked with purple
Smooth Washington clam, *Saxidomus giganteus* (page 63)

53 (49) Umbo central; siphons separate, long
California jackknife clam, *Tagelus californianus* (page 79)
Umbo at extreme anterior end; siphons united ---- 54

54 (53) Size moderate; valve slightly curved, about four times as long as wide, with yellowish periostracum; foot with dark pigment
Sickle razor clam, *Solen sicarius* (page 77)
Size small; valve straight, about five times as long as wide, with light transparent periostracum through which the flesh color of the shell usually shows; foot usually with little or no pigment
Rosy razor clam, *Solen rosaceus* (page 76)

55 (48) Pallial sinus united with pallial line; cartilage pits equal in the two valves; retracted siphons projecting beyond shell, tip with a pair of plates; umbo nearer anterior end of valve
Gaper, *Schizothaerus nuttalli* (page 89)
Pallial sinus not united with pallial line; cartilage pits unequal, that on the left valve on a conspicuous projecting tooth; retracted siphons usually not projecting beyond the shell, tip without plates; umbo not nearer anterior end of valve ---- 56

56 (55) Umbo central; valves rounded and slightly gaping at the posterior (siphonate) end ---- Soft-shell clam, *Mya arenaria* (page 90)
Umbo nearer posterior end of shell; valves truncated and widely gaping at posterior end ---- Checked borer, *Platyodon cancellatus* (page 91)

57 (46) Siphons never completely retractile ---- 59
Siphons completely retractile ---- 58

58 (57) Sides of shell at siphonal end formed in large part by soft periostracal scales; accessory plates long and slender
Scale-sided piddock, *Parapholas californica* (page 96)

Siphonal tip of valves with periostracal flap in adult specimens; accessory plate short and triangular
Flat-tipped piddock, *Penitella penita* (page 97)

59 (57) Siphon whitish covered with many blackish dot-like specks; boring end usually with short projecting spines on ridges; large adults never shelled over at anterior end Rough piddock, *Zirfaea pilsbryi* (page 95)

Siphon white with many rust brown, crescent-shaped "freckles" on outer surface; boring end a close-set series of scalloped ridges; large adults shelled over at anterior end
Wart-necked piddock, *Pholadidea ovoidea* (page 93)

# COMMON AND SCIENTIFIC NAMES


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| Eastern oyster | *Crassostrea virginica* (Gmelin 1791) | 40 |
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| Flap-tipped piddock | *Penitella penita* (Conrad 1837) | 97 |
| Wart-necked piddock | *Pholadidea ovoidea* (Gould 1851) | 93 |

# DESCRIPTIONS AND ILLUSTRATIONS

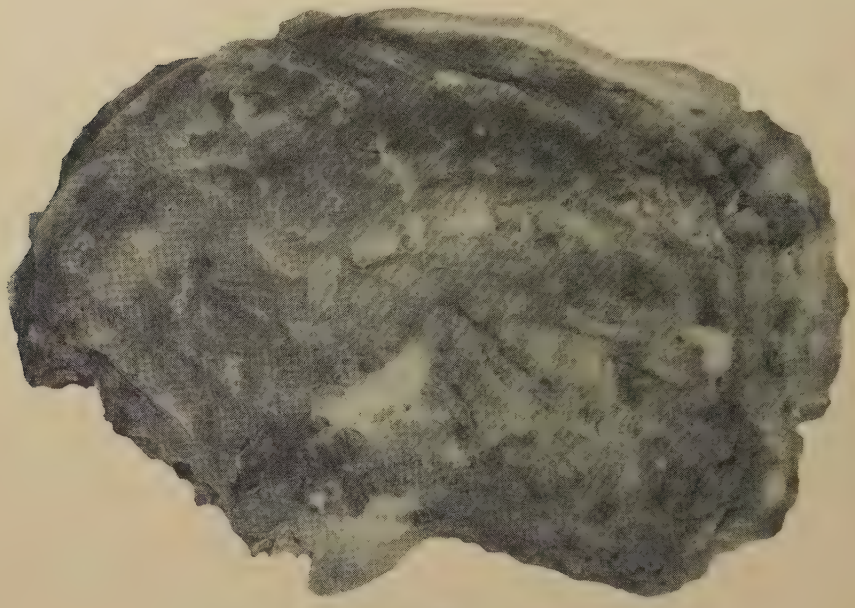

FIGURE 4

## NATIVE OYSTER
### *Ostrea lurida* Carpenter 1864

**Description:** Valves thin, irregular in shape, usually circular or elongate, sometimes scalloped at the edges. Surface of both valves flat though may conform to contours of substrate. Exterior of shells varying in color from dark grey to purplish-black. Interior of shell shiny white or olive brown. Only one adductor muscle present. Seldom exceeds two and one-half inches in length. Differs from the Eastern oyster in that it never has black adductor muscle scars and from the giant Pacific oyster in its small size and thin flat shells.

**Range:** Sitka, Alaska, to Cape San Lucas, Baja California.

**Habits:** In the Pacific Northwest it is found in beds on the surface of mud flats and gravel bars near the mouths of rivers or streams. In other localities it is found in most sheltered inlets and bays along the entire coast, attached to the shells of previous generations of oysters or any firm surface that will hold it out of the mud. These beds may cover several acres and are usually exposed at low tide. Often when not in beds these oysters are found singly or in small clusters attached to rocks, cement pilings and particularly to metal buoys, floats, etc.

**Use:** Cultivated for food in some California bays, particularly Tomales Bay. In British Columbia this species is canned and marketed under the name Olympia Oyster. Because of its small size and fine flavor it is particularly desirable for cocktails.

**Other names:** Olympia oyster, lurid oyster, rock oyster.

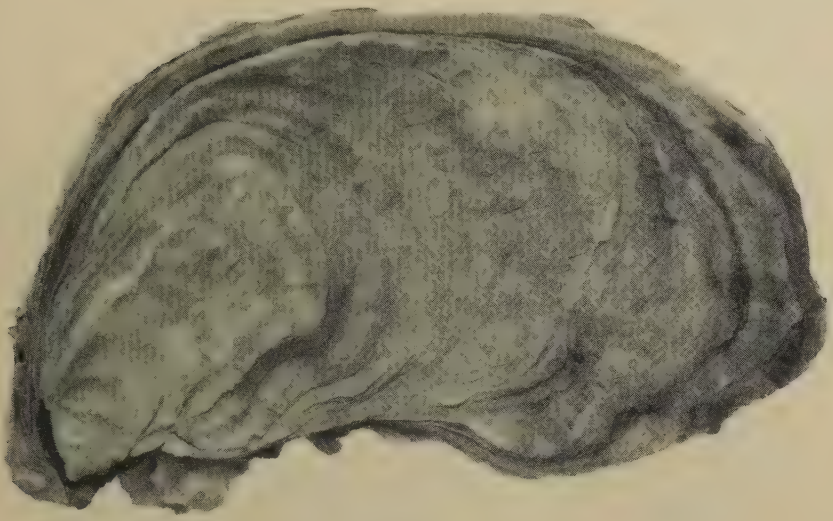

FIGURE 5

## GIANT PACIFIC OYSTER
### *Crassostrea gigas* (Thunberg 1795)

**Description:** Shell very rough, extensively fluted and laminated. Upper valve generally flat (anterior to posterior margin), lower valve deeply cupped. Color of shell whitish with many purple streaks and blotches radiating away from umbos. Shape of shell depends upon where and how grown; long and thin if in clusters in mud, and round and deep if singly on firm ground. Interior of shell shiny white, single muscle scar sometimes dark but never black. Length to 10 inches. Differs from Eastern oyster in not having black muscle scar and from the native oyster in extremely large size and heavy shell. Has been wrongly named *Ostrea laperousi* and *O. gigantea* and recently the generic name *Gryphaea* has been used (probably wrongly) for this oyster.

**Range:** British Columbia to Morro Bay, California.

**Habits:** Imported from Japan as seed and raised commercially in most of the bays of California from Morro Bay northward. There has been no substantial natural propagation of this species in California to date and all beds occurring in the State are the private property of oyster growers.

**Use:** This is not considered as fine in flavor as either the Eastern or native oyster. Use is mostly confined to sale to restaurants, as it is an ideal size for frying either whole or in pieces. Sometimes packaged and sold frozen in various retail stores.

**Other names:** Japanese oyster, giant oyster, Pacific oyster.

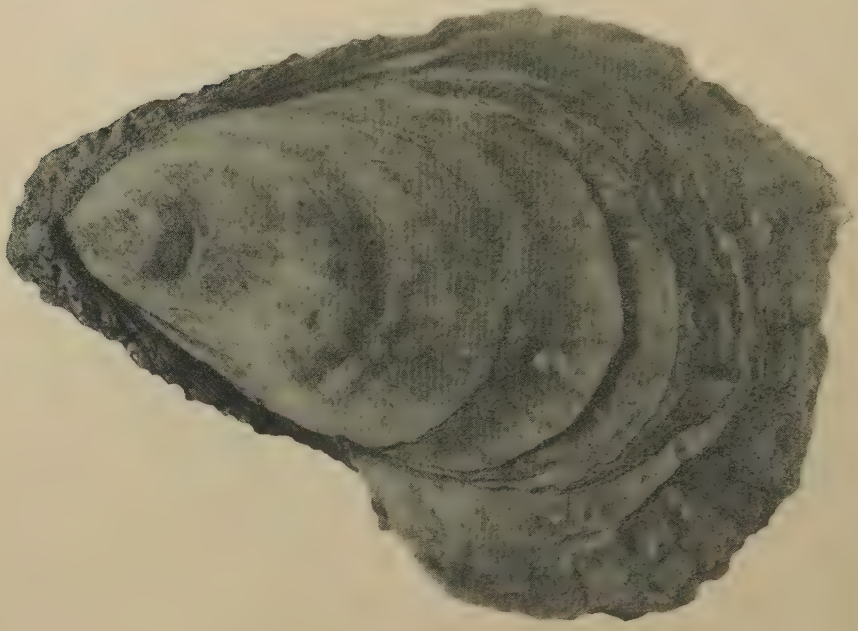

FIGURE 6

## EASTERN OYSTER
### *Crassostrea virginica* (Gmelin 1791)

**Description:** Shell widens gradually from a narrow pointed beak. Upper valve smallest and flattest with leaf-like scales of shell, lower valve deeply cupped. Exterior of shell a dingy, leaden color. Interior of shell a shiny white with black muscle scar. On our coast length to about six inches. Differs from both other species of oysters by having black muscle scars.

**Range:** British Columbia to Morro Bay, California.

**Habits:** Introduced to California waters from the Atlantic seaboard. First introductions were into San Francisco Bay around 1870. There are no natural beds of this species in California. Major plants of these oysters have been made in such bays as Humboldt, Tomales, San Francisco and Morro, but all are the property of various oyster growers.

**Use:** Raised almost entirely for human consumption. Of excellent flavor and highly esteemed raw, in cocktails, fried, in soups, etc. It is this species which is usually sold fresh or frozen by local retail markets.

**Other names:** Virginia oyster, commercial oyster.

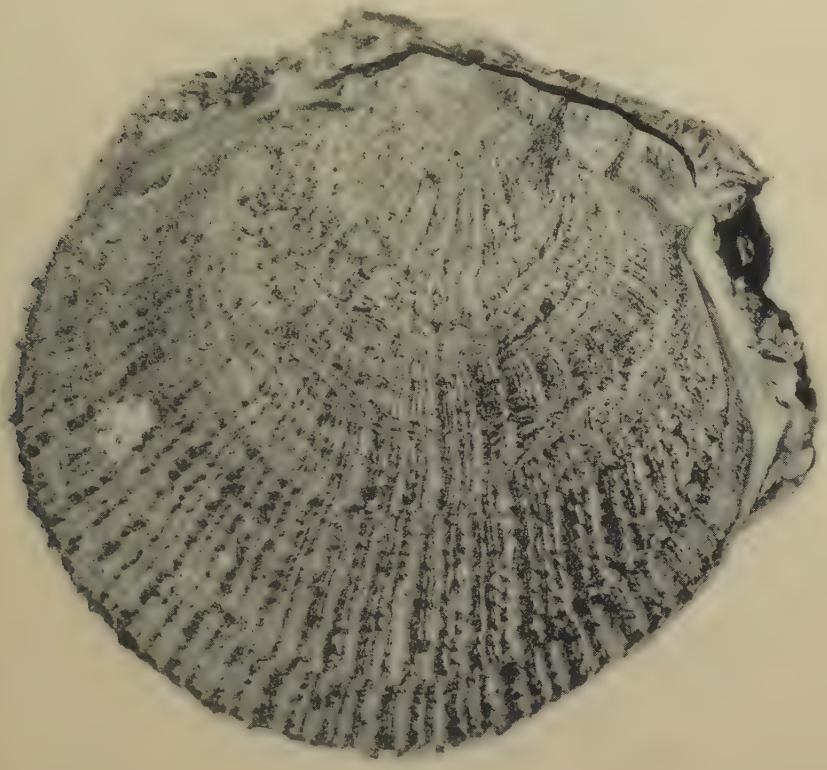

FIGURE 7

## ROCK SCALLOP
### *Hinnites multirugosus* Gale 1928

**Description:** The two valves thick and heavy, the lower often taking the shape of the rock to which it is attached. Right or attached valve retains near the umbo the shape and pattern of the young, free-swimming stage. Upper, left valve with many radiating ribs, having numerous short fluted spines. Upper valve often riddled with holes of boring sponges, worms and bivalves. Shape usually spherical. Inside of shell a shiny pearly white with distinct purple color in hinge region. Attains 10 inches in diameter though usually less than six. Differs from all other California scallops by being attached as adult and by having purple hinge area on inside of shell.

**Range:** Queen Charlotte Islands, British Columbia, to Abreojos Point, Baja California.

**Habits:** During the early part of its life it resembles the ordinary scallop in shape and its ability to swim. When slightly over an inch in diameter it becomes permanently attached to a suitable rock or other stationary object. Usually found from below high tide line on the outer coast in somewhat sheltered places into water over 100 feet deep. In Southern California the rock scallop is usually taken by skin divers along breakwaters and in rocky areas of the outer coast. In Northern California it is more frequently found closer to shore in shallower water where abalone gatherers take it at low tide.

**Use:** The single large adductor muscle or "scallop" is all that is used of this species. This muscle, sometimes two inches in diameter is sliced across the grain and fried. Definitely one of the finest scallops on the entire coast.

**Other name:** Purple-hinged scallop.

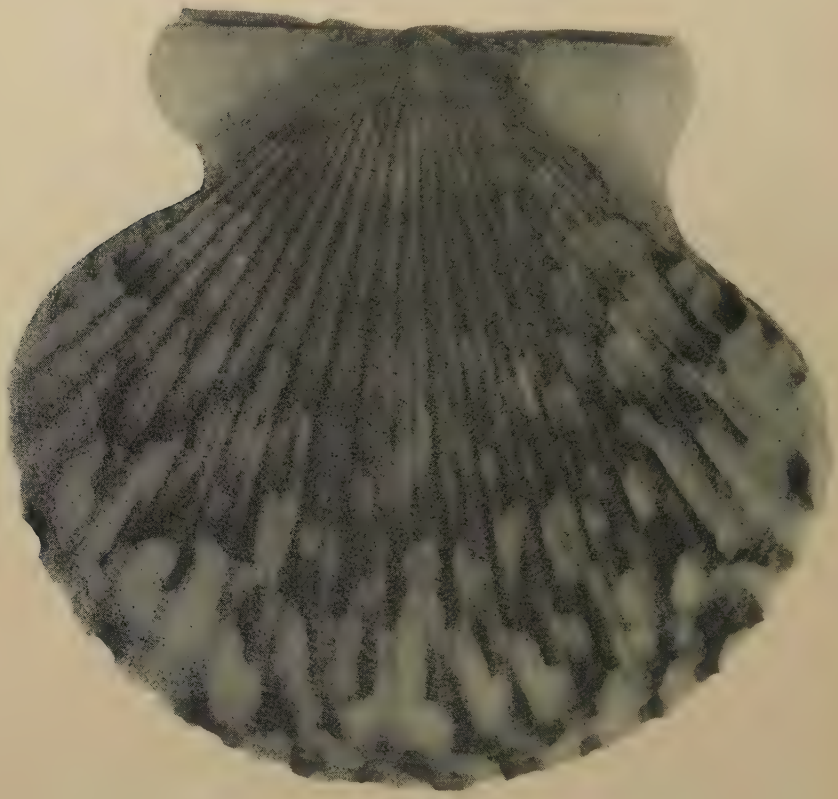

FIGURE 8

## SPECKLED SCALLOP
### *Plagioctenium circularis aequisulcatum* (Carpenter 1865)

**Description:** Rounded valves with wing-like lateral projections on each side of the umbos. About 19 to 22 flat-topped radiating ribs which interlock at the edges with those of the opposite valve. Color of shells variable from grey to orange or reddish with numerous dark spots and blotches. Left valve usually darker colored than right. Edge of mantle with short tentacle-like projections and tiny eye spots. Flesh yellowish, tinged with orange or red. Attains a diameter of three and one-half inches. Differs from the weathervane scallop by having more convex ribs, more rounded valves and spots or blotches on exterior of shells, from the San Diego scallop by having both valves rounded and from the rock scallop by being free swimming throughout life.

**Range:** Monterey Bay, California, to Cape San Lucas, Baja California.

**Habits:** Lives on the surface of sandy or muddy bottoms where it is usually covered with at least a few inches of water at low tide. Usually found inside sheltered bays, lagoons or estuaries but often in channels at entrances to these inlets or in eel grass or muddy bottoms of more quiet water on the open coast. Progresses through the water in a series of jerks, sometimes moving two or three feet at a time. Seldom taken north of Los Angeles Harbor; best California collecting localities are Alamitos, Newport and Mission Bays.

**Use:** The single large adductor muscle or scallop is all that is usually utilized though many people prefer the entire animal.

**Other names:** Pecten, fan shell, wing shell, scallop.

FIGURE 9

## SAN DIEGO SCALLOP
*Pecten diegensis* Dall 1898

**Description:** Shell regular in outline with lateral projections or wings on either side of the umbos. Right valve convex, yellowish in color and ornamented by 22 or 23 flat-topped ribs. Left or top valve flat or nearly so, reddish in color and ornamented by 21 or 22 prominent, convex-topped ribs. Attains a diameter of six inches. Differs from the other California scallops in the color of the valves.

**Range:** Cordell Bank off Bodega Bay, California, to Gorda Bank off Cape San Lucas, Baja California.

**Habits:** Occasionally observed by commercial abalone divers. This scallop usually swims a few feet off the bottom in rocky areas from five to seventy-five fathoms beneath the surface.

**Use:** The single large adductor muscle or scallop is all that is generally eaten from this species. Not often taken at present because of restrictions on drag net gear in our southern waters where this species is most abundant.

**Other name:** Butterfly scallop.

FIGURE 10

## WEATHERVANE SCALLOP
*Patinopecten caurinus* (Gould 1850)

**Description:** Valves nearly circular in outline with rather small wing-like lateral projections on each side of the umbos. Thin valves gently rounded appearing almost flat, each with about 20 low, convex ribs. Shell golden brown outside and shiny white inside. Width to about 10 inches. Differs from the speckled scallop by having gently rounded ribs, much more flattened valves and lacking spots and blotches on outside of shells; from the San Diego scallop by having both valves rounded and from the rock scallop by being free-swimming throughout life.

**Range:** Wrangell, Alaska, to Eureka, California.

**Habits:** Occurs in beds in deeper water offshore. Frequently taken in considerable numbers by the flatfish trawlers operating out of Eureka. Best localities according to these operators are in 32 to 48 fathoms from north of the Mad River south to the Eel Canyon and from the St. George Reef Light in a line toward Brookings, Oregon.

**Use:** The single large adductor muscle or scallop is all that is utilized of this species. At present there is no California fishery for the weathervane scallop but it is always eaten by the crew members of the drag boats. Excellent flavor.

**Other names:** Scallop, pecten.

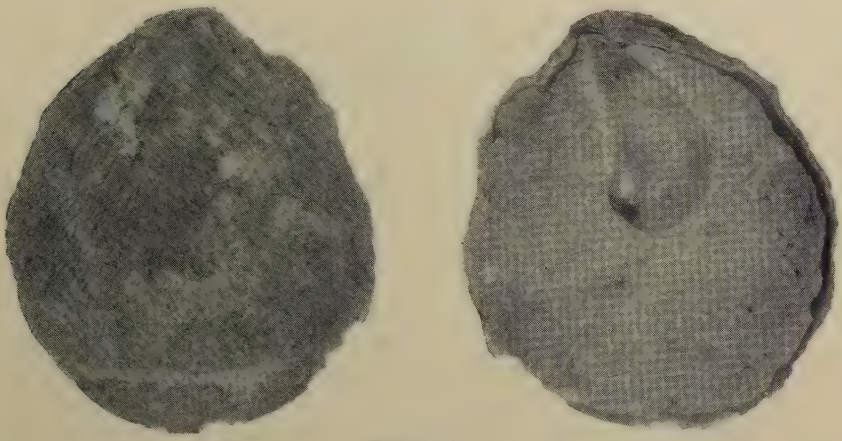

FIGURE 11

## ABALONE JINGLE
### *Pododesmus cepio* (Gray 1849)

**Description:** Shells variable in shape depending upon the shape of the object to which it is attached. Attached to rocks and shells, by a tear-drop shaped byssus which passes through a large notch in the lower or right valve. Right valve thin and fragile, fits snugly against substrate and assumes identical contour. Left valve much heavier with numerous fine, branching, radiating ridges. Interior of left valve with one large and one smaller muscle scar. Color of interior pearly grey or grey-green. To five inches in diameter but usually less than three inches. Differs from the pearly jingle in having but two muscle scars in interior or left valve and a ribbed exterior. The specific name of a northern form, *P. macroschismus*, has been wrongly associated with our abalone jingle.

**Range:** British Columbia to San Quintin Bay, Baja California.

**Habits:** Lives singly attached to rocks and shells. Most frequently observed on the shells of living abalones, sometimes two or three on a single abalone. Much more common on the red abalone, *Haliotis rufescens*, than on the other species. Occasionally found on rocks of breakwaters, road fills, etc.

**Use:** Though quite common on the abalone taken by commercial divers it is seldom removed and used for food. Said to be of quite good flavor and should be utilized by those who have access to freshly caught abalones.

**Other name:** Rock oyster.

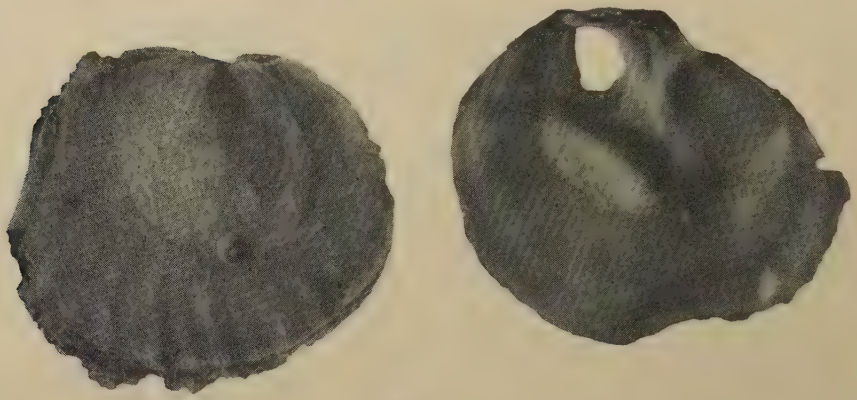

FIGURE 12

## PEARLY JINGLE
### *Anomia peruviana* d 'Orbigny 1837

**Description:** Shell variable in shape, generally fairly thin, partly translucent and smooth. Attached to rocks or shells by a byssus which passes through a large notch in the lower or right valve. Color of shell often white, coppery-brown or yellowish-green outside. Interior of left valve with one large muscle scar and two smaller ones. Length to about three inches. Differs from the abalone jingle in having three muscle scars in interior of left valve and a smooth exterior. (The third scar is formed by muscles at the base of the byssus.)

**Range:** Monterey Bay, California, to Paita, Peru, and the Galapagos Islands.

**Habits:** Lives singly attached to rocks and shells in relatively shallow water along the open coast. Seldom taken or seen alive but the great numbers of dead shells on many of our beaches indicate that it is much more common than its capture would indicate.

**Use:** Because of its small size and apparent rarity it is seldom sought for food.

**Other name:** Rock oyster.

FIGURE 13

## FAT HORSEMUSSEL
## *Volsella capax* (Conrad 1837)

**Description:** Large, thin shells covered with a heavy, glossy, brown periostracum and densely bearded from region of umbos across shell to posterior margin. Shell a brick red color in places where periostracum is worn off. Interior of shell white; flesh bright orange. Length to five inches. Differs from the straight horsemussel by having rounded, bulbous dorsal margin and from the giant horsemussel by having nearly straight ventral margin. Differs from both by having umbos at, but separate from anterior end.

**Range:** Santa Cruz, California, to Paita, Peru.

**Habits:** A solitary mussel, never found in clumps or masses. Usually attached to rocks or boulders in semi-protected areas along the open coast. Sometimes in muddy places in bays, lagoons and more quiet offshore water. If living in muddy areas, it is attached by its byssus to a rock or other solid object with just the posterior tips of shells protruding above the surface. Yellowish posterior margin of mantle usually shows when feeding under a few inches of water making it easy to find at this time. Not common anywhere in California where accessible. Small specimens are often found on the rocky reefs at Carpinteria, between Redondo Beach and San Pedro and on some of the rocks used for breakwaters.

**Use:** Due to its comparative rarity this species is not often sought for food.

**Other names:** Horsemussel, hairy mussel.

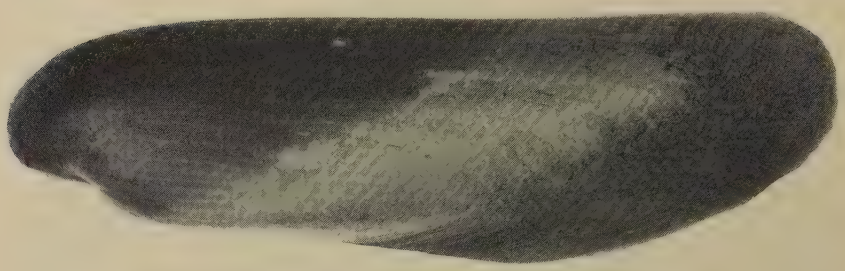

FIGURE 14

## STRAIGHT HORSEMUSSEL
### *Volsella recta* (Conrad 1837)

**Description:** Relatively narrow, elongate thin shells covered with a heavy, glossy, brown periostracum; heavily bearded on posterior quarter of shell. Interior of shell white; flesh slightly yellowish-orange. Length to six inches. Differs from the fat horsemussel in having umbo near but not at anterior end and from the giant horsemussel in having a nearly straight ventral margin.

**Range:** Bolinas Bay, California, to Ballenas Bay, Baja California.

**Habits:** A solitary mussel, never found in clumps or masses. Usually in muddy places in bays, lagoons and more quiet offshore waters. Lives embedded vertically in the mud anchored securely by a byssus and with just the posterior tips of shells protruding above the surface. Yellowish posterior margin of the mantle shows when feeding under a few inches of water making it easy to find at this time. Most common in deeper water of Los Angeles Harbor area. Sometimes found on mudflats of most bays of the State.

**Use:** Due to its comparative rarity this species is not often sought for food. Said to have a good flavor.

**Other name:** Slender horsemussel.

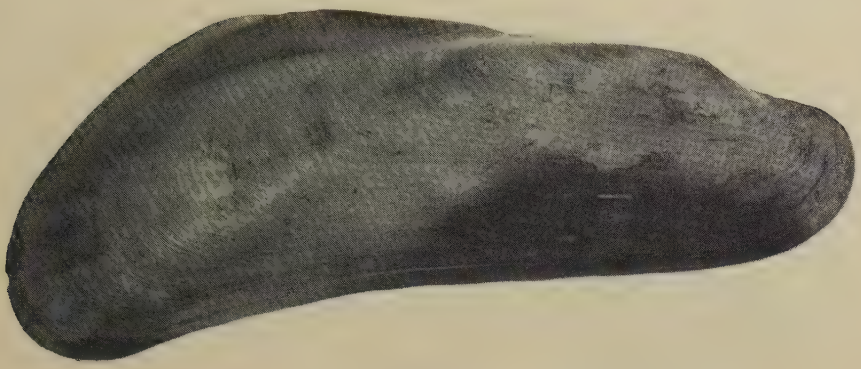

FIGURE 15

## GIANT HORSEMUSSEL
## *Volsella flabellata* (Gould 1850)

**Description:** Large, thin shells covered with a heavy, glossy, brown periostracum; lightly bearded on posterior quarter of shell. Interior of shell white; flesh slightly yellowish. Length to eight inches. Differs from the fat horsemussel in having umbo near but not at anterior end and from the straight horsemussel in having a concave ventral margin making a much broadened posterior end.

**Range:** Vancouver Island, British Columbia, to San Diego Bay, California.

**Habits:** A solitary mussel, never found in clumps or masses. Usually in muddy places in bays, lagoons and more quiet offshore waters. Lives embedded vertically in the mud, attached by a byssus and with just the posterior tips of shells protruding above the surface. Yellowish posterior margin of the mantle shows when feeding under a few inches of water making it easy to find at this time. Most common in Morro and Humboldt Bays but few even in these localities. Fairly extensive beds in 20 to 50 feet of water off Oceano area of Pismo Beach; frequently seen washed ashore in that region.

**Use:** Due to its comparative rarity this species is not often sought for food. Has a good flavor when steamed.

**Other names:** Horse mussel, big mussel.

FIGURE 16

## RIBBED HORSEMUSSEL
### *Volsella demissa* (Dillwyn 1817)

**Description:** Shell with numerous radiating ribs, particularly on posterior end. Thin, delicate shell, finely scalloped around posterior margin. Exterior of shell covered with a heavy dark brown periostracum, often badly eroded near umbos which are slightly to one side of apex. Interior of shell iridescent with a purplish tinge. Flesh a bright lemon yellow. Length to four and one-half inches.

**Range:** San Francisco Bay.

**Habits:** Ribbed horsemussels grow in large clumps, strips or mats, often several hundred individuals attached to each other by byssal threads. Frequently found attached by byssus to roots of reeds and other salt water plants in intertidal zone. To date this species has been found only in San Francisco Bay, where it was first noted in 1894. Since it was not an intentional introduction it is presumed to have been accidentally brought in with oyster shipments from the Atlantic seaboard.

**Use:** Found to be a valuable source of Vitamin D on the east coast where it is harvested in considerable quantity for use as poultry food. Seldom used as an item for human consumption.

**Other name:** Ribbed mussel.

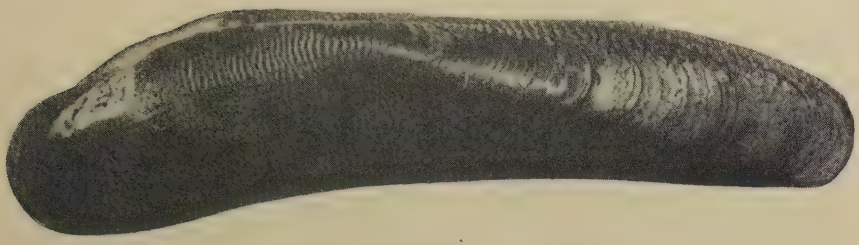

FIGURE 17

## PEA-POD BORER
### *Botula falcata* (Gould 1851)

**Description:** Long, slender, falcate shell with dull chestnut epidermis and many transverse wrinkles. Shell fragile, usually worn at beaks. Interior of shell shiny, somewhat iridescent with a metallic luster. Length to about three and one-half inches, average size about two inches.

**Range:** Coos Bay, Oregon, to Cape San Lucas, Baja California.

**Habits:** Adults live in rocks in burrows of pholads, not always filling the burrow. Attached by byssus near open end of burrow out of which posterior ends of valves protrude. Some authorities believe these mussels bore their own holes to a certain extent. Found along most of the coast where soft clay, shale or rocks are found. Not common in any locality.

**Use:** Because of small size pea-pod borers are not sought for food.

**Other names:** Rockborer, mussel.

FIGURE 18

## CALIFORNIA SEA-MUSSEL
*Mytilus californianus* Conrad 1837

**Description:** Umbo at extreme anterior end of the shell. Shell covered with a heavy, black periostracum. Older specimens when this covering is worn off are blue in color and have an eroded appearance .Exterior of shell with radiating ridges and concentric growth lines. Interior of shell bluish-black with iridescent colors showing in reflected light. Flesh a bright reddish-orange color. Length to 10 inches. Differs from the bay mussel in having up to a dozen fairly broad radial ribs.

**Range:** Aleutian Islands to Socorro Island, Mexico.

**Habits:** Attached to rocks by the byssus, sometimes in great masses between the tide lines where it is directly exposed to surf. Sometimes attached to pilings on the outer coast with the bay mussel and less frequently inside sheltered bays. It is this species which is quarantined during summer months because of toxicity (see section on mussel poisoning, page 21).

**Use:** Extensively used for fish bait along the entire coast; of less importance as an item of diet though used for food almost exclusively in some localities. Said to be one of our richest bivalves with regard to vitamin content.

**Other names:** Big mussel, sea mussel, rock mussel.

FIGURE 19

## BAY MUSSEL
### *Mytilus edulis* Linnaeus 1758

**Description:** Shell wedge-shaped with umbos at extreme anterior tip. Periostracum usually a heavy, smooth, satiny black. Interior of shell smooth, blue-black around margin with some iridescent colors in reflected light. Flesh a dull brownish-orange. Length to four inches. Differs from the California sea-mussel in having a smooth exterior, unmarked by radiating ridges and grooves.

**Range:** Arctic Ocean to Cape San Lucas, Baja California, on our coast.

**Habits:** Found in more or less sheltered areas attached to rocks, wharves, ships, pilings, etc. by means of byssal threads. Usually in dense beds at or near water level at low tide. Though found in quiet waters along the outer coast it is seldom found in the more turbulent rocky areas so typical for the California sea-mussel.

**Use:** Cultivated for market in Europe where it is highly esteemed for food. Locally used for fish bait, seldom eaten.

**Other names:** Blue mussel, pile mussel.

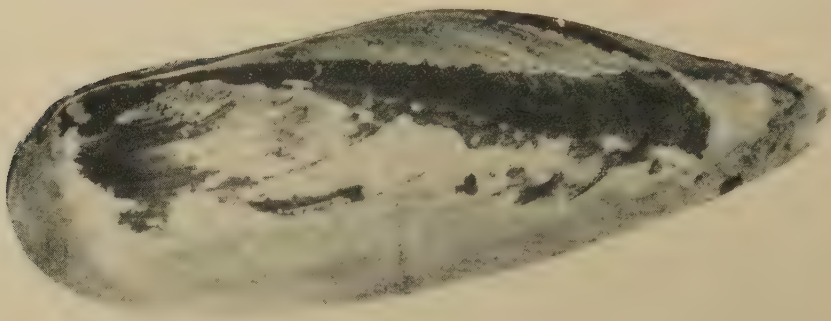

FIGURE 20

## ROCKBORING MUSSEL
### *Lithophaga plumula kelseyi* Hertlein and Strong 1946

**Description:** Slender, cylindrical shell, rounded in front and tapering behind. Two radial grooves extend back from the beaks and the space between these is frequently filled with a plume-like encrustration which projects in a symmetrical fashion beyond the ends of the valves. Shell fragile, covered with a heavy, dull, chestnut epidermis. Interior of shell shiny, somewhat iridescent with a metallic luster. Length to about three and one-half inches.

**Range:** Mendocino County to San Diego.

**Habits:** Lives in burrows in the rocks and sometimes in living shells of the abalone and rock scallop. Attached by a byssus near open end of the burrow out of which posterior ends of valves protrude. Said to enlarge its burrow by dissolving the rock or limestone with an acid produced in special glands. More common on most of the coast than the pea-pod borer; particularly common on the reefs near Carpinteria.

**Use:** Believed to have the strongest flavor of any of the bivalves here described. Because of its small size it is not often sought for food.

**Other names:** Rock-eating mussel, date mussel, date clam.

FIGURE 21

## SPINY COCKLE
*Trachycardium quadragenarium* (Conrad 1837)

**Description:** Shell large, oval, ornamented with about 40 sharply convex, radiating ribs. Numerous sharp spine-like tubercles on each rib near the margin of the shell. Exterior of valves a dull greyish-brown or buff color. Attains a length of about five inches. Differs from the other true cockles by having spines on the ribs.

**Range:** Monterey Bay, California, to Cape San Lucas, Baja California.

**Habits:** In California this species has been found in rather firm, sandy mud of bays and sloughs and in more sheltered or quiet waters of the open coast. Lives buried in the botton with just the tips of the valves projecting above the surface. Vibrations of footsteps on mudflats sometimes cause the spiny cockles to pop to the surface. This species is quite rare in California and present known beds are in water 35 to 60 feet deep off Malibu, Seal Beach and Coronado.

**Use:** Used primarily for food though not common enough to be sought in California.

**Other name:** Forty-ribbed cockle.

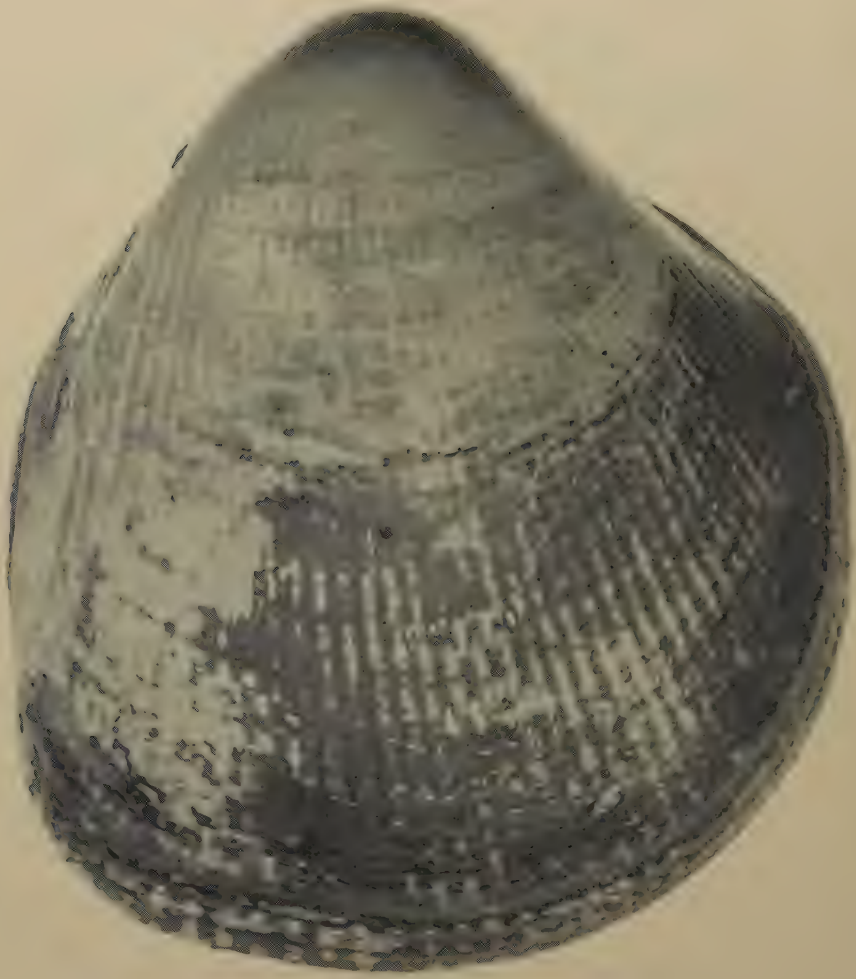

FIGURE 22

## SMOOTH GIANT COCKLE
### *Laevicardium elatum* (Sowerby 1833)

**Description:** Shells large, quite inflated, ornamented by numerous shallow, radiating grooves on the mid-portion of each valve but smooth on the anterior and posterior margins. Exterior of shell yellow in color with a thin brownish periostracum. Ventral margin of shell serrated and interlocking with opposite valve. Largest living species of *Laevicardium* known, attaining a length of nearly nine inches. Differs from other true cockles by bright yellow color of shell.

**Range:** San Pedro, California, to Panama.

**Habits:** In California there are still a few of these cockles living in the rather quiet water offshore between Seal Beach and Huntington Beach. Farther south and in the Gulf of California the giant cockle lives in sandy mud exposed at low water. With this species as with the spiny cockle, vibrations caused by walking heavily on these mud flats will often make the cockle pop to the surface.

**Use:** Used primarily for food though not common enough to be sought in California.

**Other names:** Horses hoof shell, yellow cockle, smooth cockle.

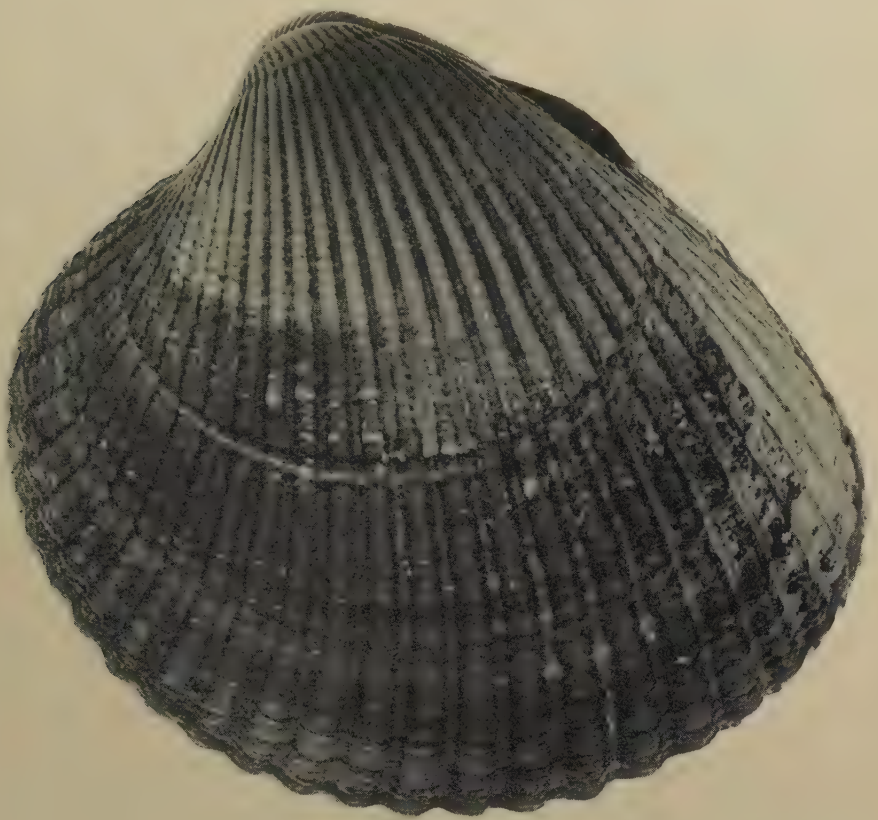

FIGURE 23

## BASKET COCKLE
### *Clinocardium nuttalli* (Conrad 1837)

**Description:** Shells large and inflated, ornamented by about 34 bold, radiating, convex ribs separated by grooves which are prolonged at the margin to form interlocking points. Exterior of shell marked by concentric lines of growth, particularly in large individuals. Specimens over three inches in width usually with a thick, brownish periostracum, smaller cockles mottled with brownish or reddish on buff colored shell. Attains a length of four and one-half inches. Differs from giant cockle by having brownish colored shell and prominent radiating ridges and grooves and from spiny cockle by having no projections on ribs.

**Range:** Bering Sea to San Diego, California.

**Habits:** Found in mud, or muddy sand of bays, sloughs and estuaries and in relatively shallow water in more quiet or protected areas on the open coast. Lives on the surface or just beneath it. When covered by water the basket cockle often has shell gaping to feed. Yellowish-white edges of mantle which form siphons are readily seen at these times and cockles may be picked out of mud with fingers. No extensive beds in California but at times may be gathered in some numbers in the Le Grande area of Pismo Beach, along the beach north of Morro Rock and in Elkhorn Slough, Monterey Bay.

**Use:** Highly esteemed for food but usually not common enough in California to be sought after. Those sold in the markets, and restaurants are usually shipped from Puget Sound and British Columbia where they are quite extensively fished.

**Other names:** Heart cockle, quahog.

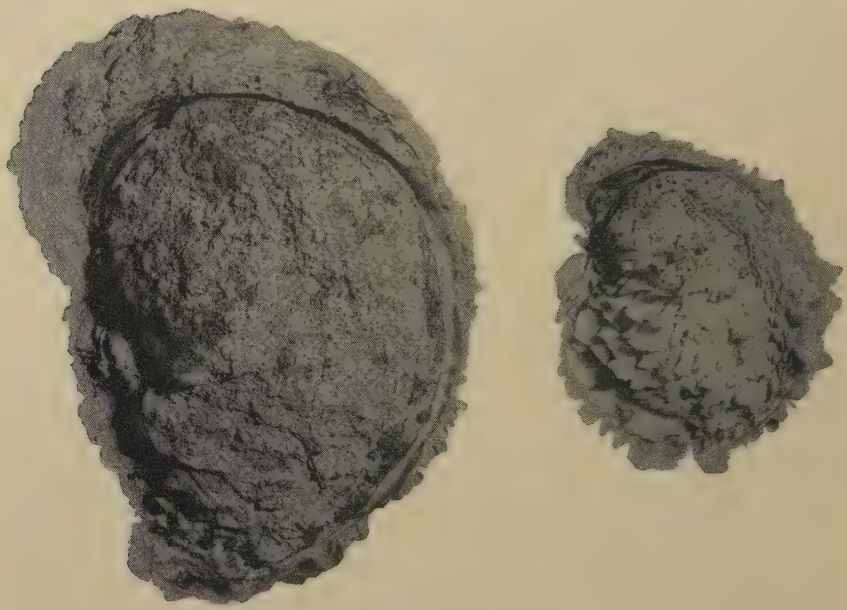

FIGURE 24

## AGATE CHAMA
### *Chama pellucida* Sowerby 1835

**Description:** Shell firm and strong and the surface roughened by the concentric frills, which are somewhat translucent. Usually white, sometimes tinged with red or pink. Frills badly worn on specimens attached to rocks but usually in excellent condition on specimens attached to floating wood. The curve of the upper valve is to the right or clockwise. Differs from the California reversed chama in attachment by left valve (California reversed chama attached by right.) Average size about one inch in diameter but ranges to two and one-half inches.

**Range:** Oregon to Chile.

**Habits:** Attached to rocks, planks and other solid objects. Often in large clusters with the California reversed chama on rocks along most of the open coast. Seldom in bays or more quiet coastal waters. These clams are not secretive in their habits but are found attached over most of the exposed surfaces in typical habitat. Frequently camouflaged by a coating of algae making them difficult to see.

**Use:** The agate chama is of excellent flavor but because of the small amount of flesh for the size of the shell and the difficulty of removing the meat it is not often sought for food.

**Other names:** Rock oyster, frilled hoof shell.

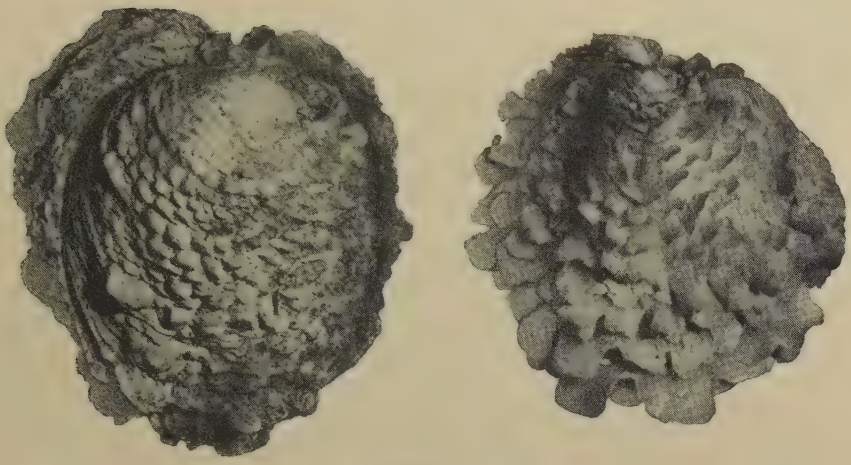

FIGURE 25

## CALIFORNIA REVERSED CHAMA
### *Pseudochama exogyra* (Conrad 1837)

**Description:** Shell firm and strong and the surface roughened by the concentric frills, which are somewhat translucent. Usually white, sometimes tinged with red or pink. Frills badly worn on specimens attached to rocks but usually in good condition on specimens attached to floating wood. Curve of upper valve is to the left. Differs from the agate chama in attachment by right valve (agate chama attached by left). Average size about one inch in diameter but ranges to two and one-half inches.

**Range:** Oregon to Panama.

**Habits:** Attached to rocks, planks and other solid objects. Often in large clusters with the agate chama on rocks along most of the open coast. Seldom in bays or more quiet coastal waters. These clams are not secretive in their habits but are found attached over most of the exposed surfaces in typical habitat. Frequently camouflaged by a coating of algae making them difficult to see.

**Use:** The reversed chama is of excellent flavor but because of the small amount of flesh for the size of the shell and the difficulty of removing the meat it is not often sought for food.

**Other names:** Rock oyster, frilled hoof shell, false chama.

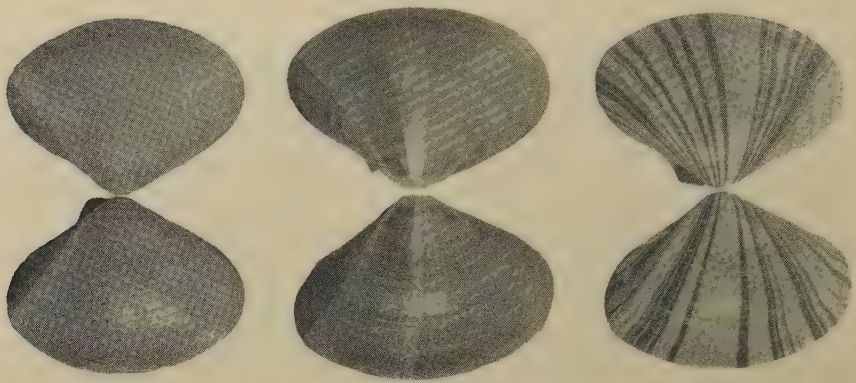

FIGURE 26

## PISMO CLAM
### *Tivela stultorum* (Mawe 1823)

**Description:** Valves large, thick and massive, covered with a heavy, varnish-like coat of periostracum. Angle formed at the umbo by the anterior and posterior margins is symmetrical. Hinge ligament external, quite prominent. Color variable, particularly in young individuals, ranging from pale buckskin to dark chocolate. Occasional individuals marked with chocolate brown lines radiating from the umbo. Attains a length of about seven and one-quarter inches. Symmetrical triangular shape, thick hard shell, and typical habitat distinguish this species from all others in the same family.

**Range:** Halfmoon Bay, California, to Magdalena Bay, Baja California.

**Habits:** Usually lives in the intertidal zone on flat sandy beaches of the open coast exposed to the full force of the surf. Has been taken in 80 feet of water, and off some of the Southern California beaches large clams are seldom found in less than 20 feet of water. Sometimes found in entrance channels to bays, sloughs or estuaries. This species is a relatively slow digger and seldom burrows more than six inches into the sand. Best localities in the intertidal zone are Pismo Beach, Morro Bay, and the area in Monterey Bay between Elkhorn Slough and Santa Cruz.

**Use:** The flesh of this clam is highly esteemed for food and it is the subject of an extremely heavy fishery in California. Used to a minor extent for fish bait. Shells are used for souvenir ashtrays, etc.

**Other name:** Giant tivela.

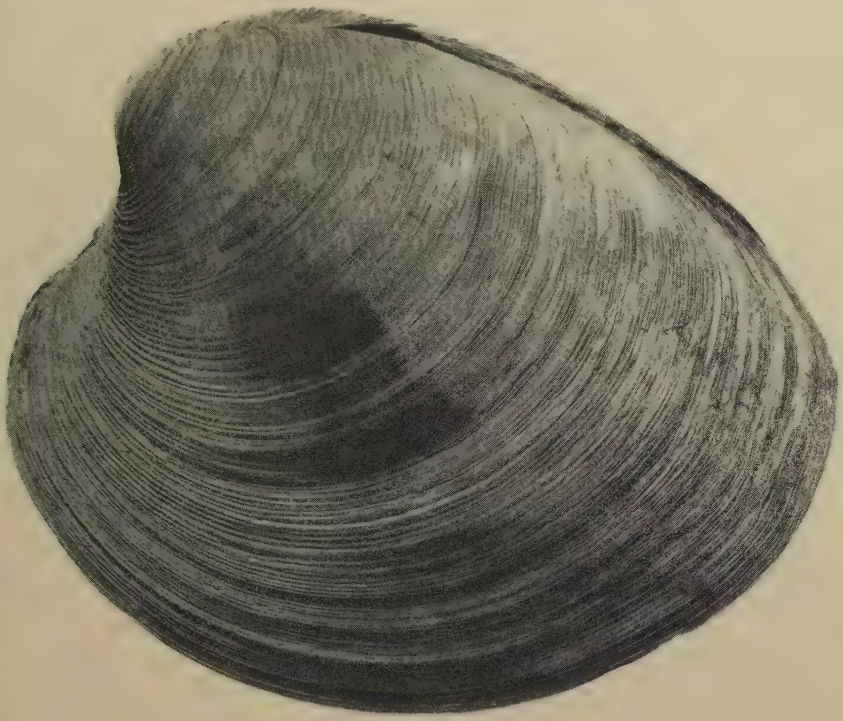

FIGURE 27

## QUAHOG
### *Venus mercenaria* Linnaeus 1758

**Description:** Heavy, compact valves ornamented with prominent concentric ridges, particularly near the anterior and posterior ends and the umbo. Shell covered with a heavy yellowish-brown periostracum and often stained nearly black near the center of each valve. A distinct, heart-shaped lunule. Hinge ligament prominent, external. Ventral margin of shell deeply crenulate. Inside of shell porcellanous white, with deep violet blotches near the muscle scars, and a purple or violet border around the ventral margin. Attains a length of four and one-half inches. Differs from all littleneck clams and chiones by not having apparent radial sculpture.

**Range:** Humboldt Bay, California.

**Habits:** There is a small bed of quahogs in Humboldt Bay which possibly resulted from accidental introduction in a shipment of eastern oysters from the Atlantic coast. The clams from this bed in Humboldt Bay may be the supposed native species *Venus kennicotti* (Dall 1871) but some systematic work must be done before this can be determined. This quahog is found living just beneath the surface in firm sand or sandy mud in the intertidal zone in a restricted area of Humboldt Bay. The species may get started in other bays of California, particularly since shellfish dealers ship it alive from the East Coast and hold it in receivers for long periods of time.

**Use:** Highly esteemed for food on the Atlantic Coast and the object of a heavy sport and commercial fishery there. Shipped in large quantities to California where it is sold to restaurants and others as quahogs, cherry stone clams, hard shell clams, etc. The shells of this clam were used by the eastern Indians for wampum, cutting small pierced beads of white and purple to string for this purpose.

**Other names:** Round clam, hard-shell clam, littleneck clam, cherrystone clam.

FIGURE 28

## WHITE AMIANTIS
### *Amiantis callosa* (Conrad 1837)

**Description:** Heavy, pure white shell with no radiating ribs but numerous concentric, rounded ridges which occasionally branch. Valves covered with a smooth, shiny periostracum. Ligament external but not prominently raised. Attains a length of five inches. Differs from the Pismo clam by not being as triangular in shape and by having the numerous, rounded, concentric ridges. Differs from all other clams in the same family by having rounded concentric ridges and pure white color.

**Range:** Santa Barbara, California, to Cape San Lucas, Baja California.

**Habits:** Lives on open, sandy beaches near the entrances to bays, lagoons, and estuaries and in more sheltered or quiet waters along the outer coast. Normally this species is beyond the area exposed at extreme low tides but seldom in more than 20 to 25 feet of water. It may sometimes be gathered by the dozens along the beach after being washed ashore by heavy coastal storms. Not common anywhere in California with the possible exception of the offshore area between Sunset Beach and Huntington Beach in Southern California.

**Use:** Said to be of excellent flavor but due to its comparative rarity is not subject to a fishery.

**Other name:** Sea cockle.

FIGURE 29

## SMOOTH WASHINGTON CLAM
### *Saxidomus giganteus* (Deshayes 1839)

**Description:** Shell thick and firm, oval in outline but more rounded than that of the common Washington clam. Outer surface with such finely spaced concentric growth lines as to seem almost smooth. Interior of shell entirely white, never with purple markings near siphonal end of shell. Attains a length of four and one-half inches. Differs from the common Washington clam by lacking purple marks on inside of shell at posterior end and from the thin-shelled littleneck, which is sometimes mistaken for it, by not having radiating ridges.

**Range:** Sitka, Alaska, to San Francisco Bay, California.

**Habits:** Lives at depths of 10 to 14 inches or more in mud or sandy mud of bays, lagoons and estuaries in areas which are usually exposed at low tide. In firm mud a narrow slit-like mark about one-quarter inch long indicates the spot where the long siphon tube reaches the surface. This is a more northern species than the common Washington clam and is seldom taken south of Humboldt Bay. In only one locality in California, near Fields Landing, Humboldt Bay, is this species common enough to support a minor fishery.

**Use:** Highly esteemed for food.

**Other names:** Butter clam, money shell, giant saxidome.

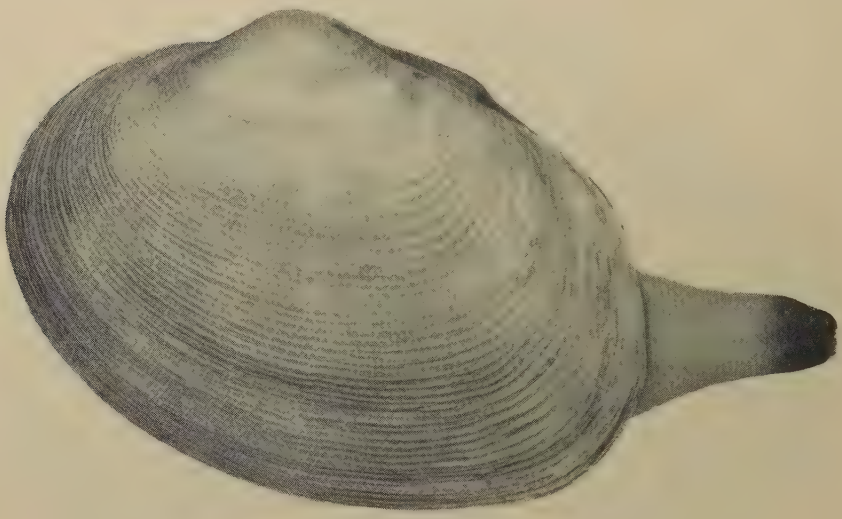

FIGURE 30

## COMMON WASHINGTON CLAM
*Saxidomus nuttalli* Conrad 1837

**Description:** Shell thick and firm, oval in outline and roughened on the outer surface by numerous concentric ridges. Shell gapes slightly at siphonal end and siphons though completely retractile can usually be seen through the gape. Inside of shells shiny white with dark purple at posterior (siphonal) end. Attains a length of nearly seven inches. Differs from the smooth Washington clam by having purple markings on inner margin of shell at siphonal end and from the thin-shelled littleneck, which is sometimes mistaken for it, by not having radiating ridges.

**Range:** Humboldt Bay, California, to San Quintin Bay, Baja California.

**Habits:** Lives at depths of 12 to 18 or more inches in mud, sandy mud or sand of bays, lagoons and estuaries in areas which are usually exposed at low tide. Siphons joined to form a tube which extends to the surface of the mud. On firm, sandy mud a narrow slit-like mark at the surface, one-half inch or less in length, indicates the presence of this clam. Siphons are seldom withdrawn rapidly enough to squirt water above the surface of the mud. One of the more important clams in the sheltered waters north of Morro Bay, seldom found in the bays to the south. Best localities in California are Morro Bay, Elkhorn Slough, Bodega Bay, Tomales Bay and Humboldt Bay.

**Use:** Highly esteemed for food and the object of an extensive fishery in the northern part of the State. Sometimes used for fish bait.

**Other names:** Butter clam, money shell, giant saxidome, sand cockle.

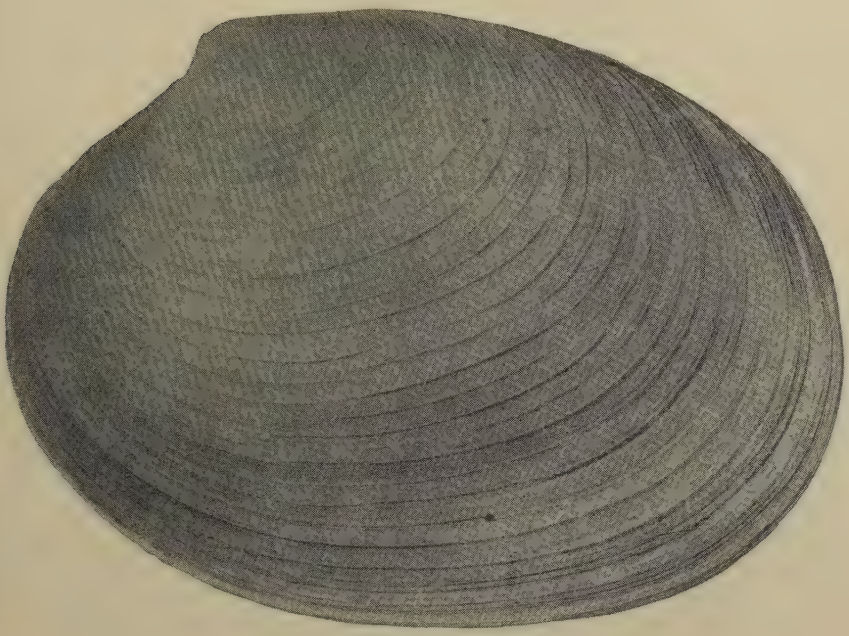

FIGURE 31

## THIN-SHELLED LITTLENECK
*Protothaca tenerrima* (Carpenter 1856)

**Description:** Valves thin, elongate, oval and much less inflated than other species of littlenecks. Concentric ridges prominent; radiating ribs faint, scarcely noticeable. Pallial sinus deep, reaching two-thirds of distance to anterior muscle scar. Ventral margin of shell smooth, never crenulate. Attains a length of five inches. Differs from other littlenecks and chiones by having pallial sinus extend two-thirds of distance to anterior muscle scar. Sometimes mistaken for a Washington clam, from which it differs by shell margin not gaping at posterior (siphonal) end.

**Range:** British Columbia to Magdalena Bay, Baja California.

**Habits:** Mostly found in firm, sandy mud of bays, sloughs and estuaries at depths of 10 to 16 inches beneath the surface. Frequently found in the same habitat and in conjunction with Washington clams for which it is mistaken. Not common anywhere within its range but most likely to be dug in Morro Bay or Elkhorn Slough. A favorite food of the moon snail; many dead shells are found which have been drilled by this snail.

**Use:** Highly esteemed for food but usually so rare and so deep underground as to be taken only incidentally by diggers seeking Washington clams.

**Other names:** Thin shell cockle, finest carpet shell, cockle.

FIGURE 32

## COMMON LITTLENECK
### *Protothaca staminea* (Conrad 1837)

**Description:** Oval, inflated valves ornamented by well defined, radiating ribs and less prominent, concentric ridges. Lunule often only faintly defined. Ventral margin slightly crenulated. Pallial sinus extending slightly over one-half way to anterior adductor muscle. Color highly variable, yellowish grey or grey in sloughs and bays, and along the open coast often whitish with geometric patterns of wavy brown lines or blotches on sides. Attains a length of two and one-half inches. Differs from chiones and Japanese littleneck in having pallial sinus extend more than half way to anterior adductor muscle, and from rough-sided and thin-shelled littleneck in having radiating ribs more prominent than concentric ridges.

**Range:** Aleutian Islands to Cape San Lucas, Baja California.

**Habits:** Often found in coarse, sandy mud of bays, sloughs and estuaries, seldom more than two or three inches beneath the surface. On the open coast the species is found in nearly any area where there is a rocky point or reef made up of generally small cobbles with a coarse sand underneath. In these areas the large stones and boulders must be moved aside and the coarse sand beneath these dug up to find these clams. Extremely common at Malibu Point and San Mateo Point south of San Clemente, less common on numerous other points of Central and Northern California. Good beds also exist in Bodega and Tomales Bays.

**Use:** Highly esteemed for food and much sought throughout the entire State by both sport and commercial diggers.

**Other names:** Rock cockle, bay cockle, hard shell clam, Tomales Bay cockle, rock clam, ribbed carpet shell.

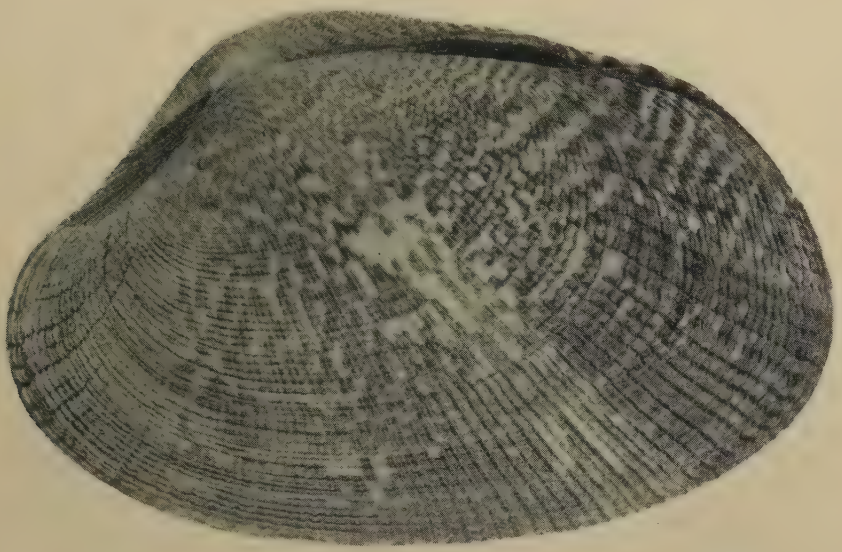

FIGURE 33

## JAPANESE LITTLENECK
### *Tapes semidecussata* Reeve 1864

**Description:** Elongate, oval valves ornamented by well defined, radiating ribs and less prominent, concentric ridges. Radiating ribs particularly heavy and conspicuous at posterior end. Inside ventral margins of shell smooth. Pallial sinus extending less than half-way to anterior muscle scar. Hinge ligament external, prominent. Color highly variable, mostly yellowish or buff with geometric patterns of wavy brown or black lines and blotches on sides. Attains a length of three inches. Differs from other littlenecks by short pallial sinus, extending less than half way to anterior muscle scar, and from chiones in the very prominent radiating ribs and rounded pallial sinus. There are many differences of opinion among systematists on the proper genus in which to place this clam. It has been called *Tapes*, *Venerupis*, *Paphia* and *Protothaca* but seems best fitted to *Tapes*.

**Range:** British Columbia to Elkhorn Slough, California.

**Habits:** Mostly found in coarse, sandy mud of bays, sloughs and estuaries seldom more than an inch or two beneath the surface. This clam is not native to California but was accidentally introduced into San Francisco Bay around 1930. Whether it came in with seed of the giant Pacific oyster or was purposely brought in by a Japanese is not known. It is a welcome addition to our fauna and it is hoped it can be introduced into Southern California bays at a future date.

**Use:** Highly esteemed for food and much sought in San Francisco Bay where it is extremely common. Due to pollution in San Francisco Bay extreme care should be taken to cleanse these clams properly before eating.

**Other name:** Japanese cockle.

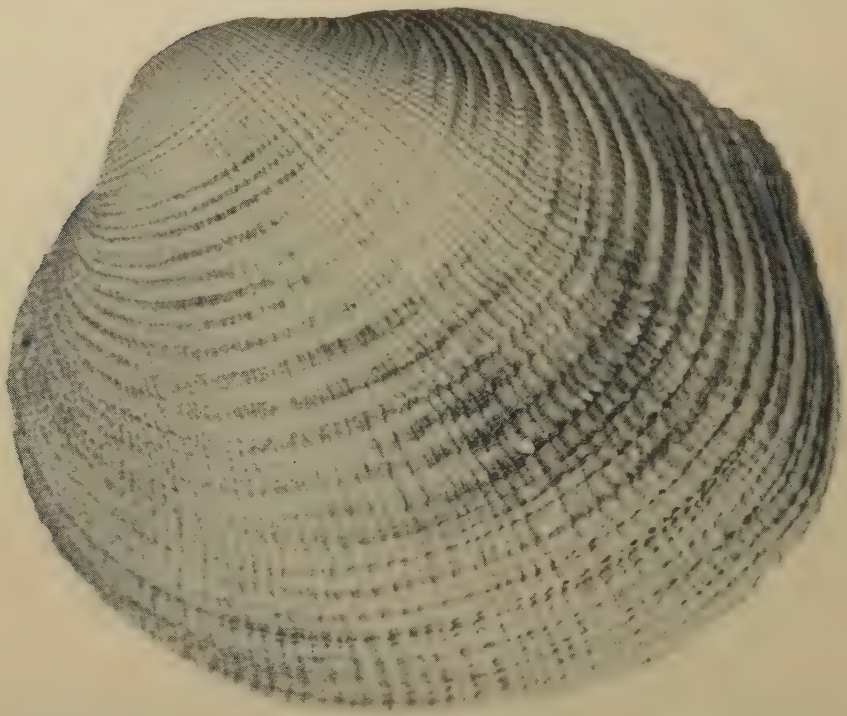

FIGURE 34

## ROUGH-SIDED LITTLENECK
### *Protothaca laciniata* (Carpenter 1864)

**Description:** Heavy valves, nearly rounded in outline and sculptured with radiating ribs and concentric ridges which are equally prominent. Small, rough tubercles present at intersections of radiating ribs and concentric ridges giving the outside of the shell a rasp-like feel. Pallial sinus extends more than half way to anterior muscle scar. Color mostly buff to orange-brown, often with dark mud stains. Attains a length of four inches. Differs from other littlenecks by extremely roughened exterior and from chiones in the long pallial sinus extending more than half way to anterior muscle scar.

**Range:** Elkhorn Slough, Monterey Bay, California, to Estero Bay, Baja California.

**Habits:** Mostly found in firm, sandy mud of bays, sloughs and estuaries and in the semi-protected quiet waters of the open coast. Clams up to two inches in diameter are seldom more than two or three inches beneath the surface but large specimens may be as much as 8 or 10 inches. These are not so common as the other littlenecks and only in Alamitos Bay have they been taken in any quantity. Have been taken in water 20 to 25 feet deep off Seal Beach.

**Use:** Highly esteemed for food but usually so rare as to be taken only incidentally with other littlenecks.

**Other names:** Rough cockle, bay cockle.

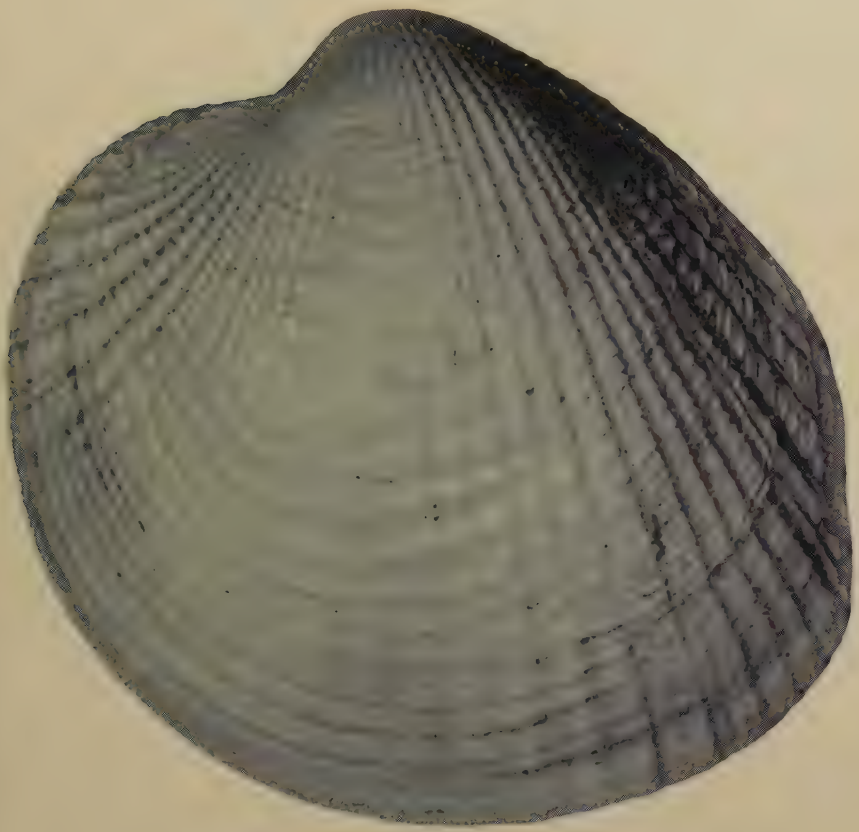

FIGURE 35

## SMOOTH CHIONE
### *Chione fluctifraga* (Sowerby 1853)

**Description:** Heavy, compact valves ornamented with prominent, radiating ribs and grooves and less prominent, concentric ridges. Radiating ribs more prominent at the posterior (siphonal) end of the shell than elsewhere. No distinct lunule. Shell covered with a heavy, grey or yellowish brown periostracum but often so badly eroded as to seem chalky. Largest of the three chiones found in California, attaining a length of three and one-half inches. Differs from the other two chiones by not having distinct lunule and from littleneck clams by having extremely shallow, angular pallial sinus.

**Range:** Santa Barbara, California, to Cape San Lucas, Baja California.

**Habits:** In California found in mud flats of back bays and sloughs, seldom north of San Pedro. Usually found within an inch of the surface in areas exposed by low tide. Best localities in California are Alamitos Bay, Anaheim Slough, Newport Bay, San Diego Bay and Tijuana Slough.

**Use:** Highly esteemed for food and the object of an extensive sport and commercial fishery in Southern California.

**Other names:** Hard shell cockle, cockle, mud cockle, bay cockle.

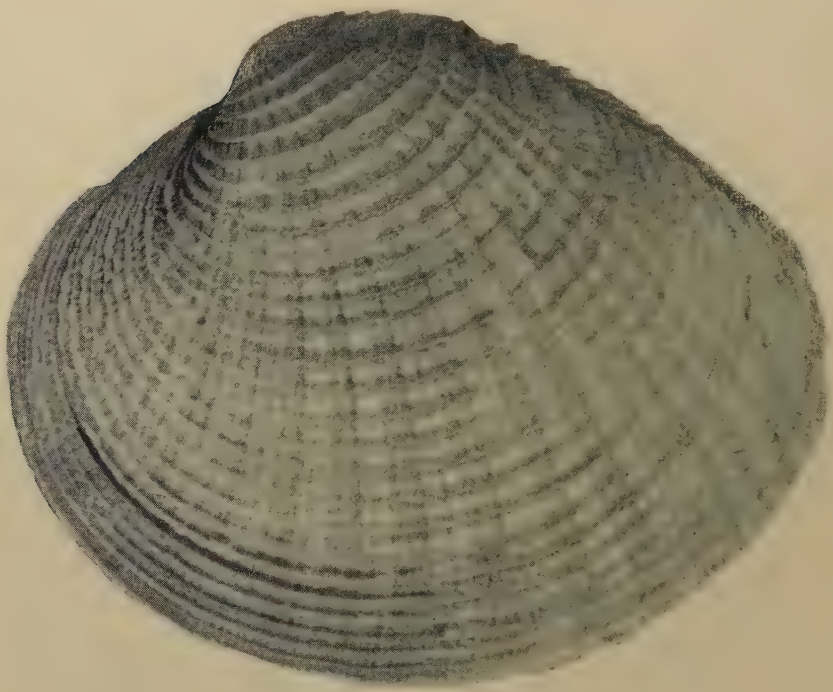

FIGURE 36

## WAVY CHIONE
### *Chione undatella* (Sowerby 1835)

**Description:** Heavy, compact valves ornamented with numerous, closely spaced, sharp and thin, concentric lamellae. Radiating ribs fairly conspicuous over entire shell, including lamellae. Conspicuous lunule present. Attains a length of two and one-half inches. There is some question as to the applicability of the specific name *undatella* but until some critical work is done on the genus *Chione* this name must remain. Differs from the smooth chione in having a lunule and from the banded chione in having sharp lamellae.

**Range:** Goleta, California, to Cape San Lucas, Baja California. (Southern limit given as Peru by some authors.)

**Habits:** Found in mud flats of back bays and sloughs, seldom north of San Pedro. Usually found at or very near the surface, seeming to prefer a more firm, sandy mud habitat than the smooth chione, usually nearer to the entrances to bays. Best localities in California are Alamitos Bay, Anaheim Slough, Newport Bay and San Diego Bay.

**Use:** Highly esteemed for food and the object of an extensive sport and commercial fishery in Southern California.

**Other names:** Hard shell cockle, cockle, mud cockle, bay cockle.

FIGURE 37

## BANDED CHIONE
### *Chione californiensis* (Broderip 1835)

**Description:** Heavy compact valves, ornamented with rather widely spaced, slightly reflexed, concentric lamellae which toward the middle of the valve become crowded and flattened and toward the posterior (siphonal) end tend to fade out. Lamellae usually so reflexed and flattened as to present a smooth polished surface. Distinct lunule present. Shells covered with a thin, yellowish-brown periostracum. Attains a length of two and one-half inches. There is some question as to the applicability of the specific name *californiensis* but until some critical work is done on the genus *Chione* this name must remain. Differs from the smooth chione in having a lunule and from the wavy chione in having smooth, reflexed concentric lamellae.

**Range:** Carpinteria, California, to Cape San Lucas, Baja California. (Southern limit given as Panama by some authors.)

**Habits:** Found in the mud flats of back bays, sloughs and estuaries in much the same habitat as the wavy chione but ranging into deeper water. This is the rarest of the three California species of *Chione* and is not too often taken alive, though dead shells are not uncommon. Most often found in Alamitos Bay and Anaheim Slough.

**Use:** Highly esteemed for food. Taken incidentally with the smooth and wavy chiones.

**Other names:** Hard shell cockle, cockle, mud cockle, bay cockle.

FIGURE 38

## YELLOW APOLYMETIS
### *Apolymetis biangulata* (Carpenter 1855)

**Description:** A fairly large clam, nearly circular in outline and having asymmetrical valves. The posterior (siphonal) end of the deeper valve has two angular grooves. Shell covered with a thin, brownish periostracum which is usually badly eroded near the center of the valves. Shells yellowish-brown, ornamented with numerous fine, concentric lines. Attains a length of three inches.

**Range:** Point Conception, California, to San Quintin, Baja California.

**Habits:** Found in coarse sand and gravel under or near boulders and cobbles along rocky areas of the outer coast. Not very active when disturbed. Nowhere common on the coast of California. Best general locality is the rocky area between Redondo Beach and San Pedro.

**Use:** Said to be of excellent flavor. Due to its comparative rarity it is not the object of a fishery.

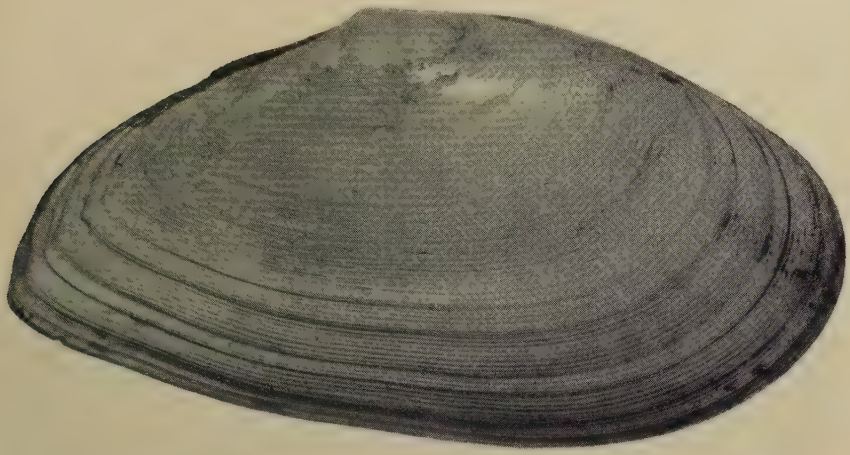

FIGURE 39

## BODEGA TELLEN
### *Tellina bodegensis* Hinds 1845

**Description:** Long and flat, rounded at anterior end and more or less pointed at posterior (siphonal) end. Shells white with a smooth polished surface ornamented with numerous fine, regular, concentric ridges. Siphonal end bent slightly to the right. Attains a length of two and one-half inches. Differs from bent-nose clam by having numerous concentric ridges.

**Range:** Queen Charlotte Islands, British Columbia to Cape San Lucas, Baja California.

**Habits:** Found on most sandy beaches along the outer coast and particularly in the coarse, shifting sand near the entrances to bays, lagoons and estuaries. An active clam burrowing rapidly if disturbed. Dead shells are often found along the beaches but live clams are nowhere common in California.

**Use:** Excellent flavor but due to its comparative rarity it is not the object of a fishery.

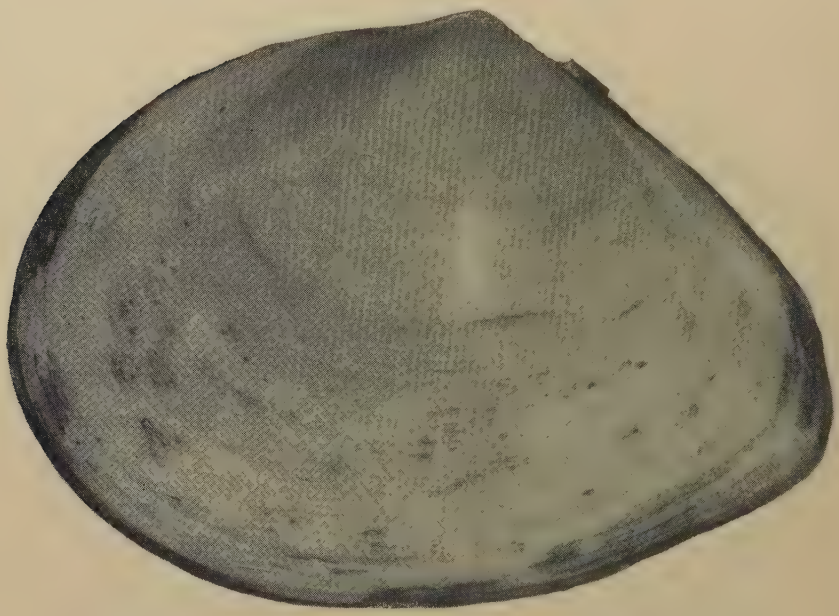

FIGURE 40

## BENT-NOSE CLAM
### *Macoma nasuta* (Conrad 1837)

**Description:** Smooth, white shell covered with a thin, grey periostracum. Anterior end rounded, posterior (siphonate) end elongated and bent to the right. Valves light and thin, especially at the edges. Siphons separate and very long. Attains a length of two inches. Differs from the white sandclam by having valves bent to right at posterior end and from the Bodega tellen by having a smooth shell.

**Range:** Kodiak Island, Alaska, to Cape San Lucas, Baja California.

**Habits:** Mostly found in heavy mud or muddy sand of sheltered bays, lagoons and estuaries. These clams always lie on the left side and may be at depths of four to eight inches beneath the mud. Siphons are extended to the surface for feeding and are freely withdrawn and re-extended to a different spot. There are few surface indications as to the presence of this species but it is often one of the most common clams in muddier, quiet areas of all the protected inlets on the California coast.

**Use:** Though comon and of excellent flavor the bent-nose clam is seldom used for food because it is so filled with mud it is extremely difficult to clean. The only way to purge this clam thoroughly of mud is to keep it alive for several days in constantly changed sea water.

**Other name:** Mud clam.

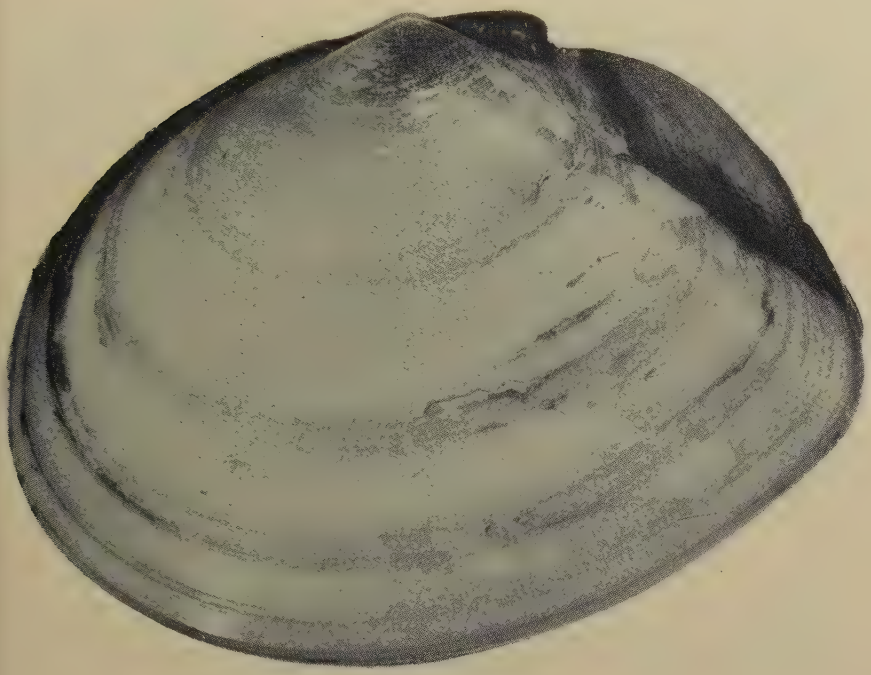

FIGURE 41

## WHITE SANDCLAM
### *Macoma secta* (Conrad 1837)

**Description:** Smooth, white shell covered with a thin, grey periostracum. Left valve flatter than right but the siphonate end is never elongate nor bent. Valves light and thin, especially at the edges. Siphons separate and very long. Hinge ligament external and protruding. Attains a length of four and one-half inches. Differs from the bent-nose clam and the Bodega tellen in having straight valves at posterior end.

**Range:** British Columbia to Cape San Lucas, Baja California.

**Habits:** Usually found in clean sand or sandy mud of bays, lagoons and estuaries nearer the entrances than the bent-nose clam. Sometimes found in water 10 to 30 feet deep along the outer coast in areas protected by points of land, breakwaters, etc. Small clams sometimes are within a few inches of the surface but large individuals may be at depths of 18 or more inches beneath the sand. Not so common as the bent-nose clam. Best localities are Elkhorn Slough and Morro Bay. There are good beds of large white sandclams in the area beyond the surf between Seal Beach and Huntington Beach.

**Use:** Excellent flavor and seldom muddy as is the bent-nose clam. Due to the depths at which it is found and the lack of visible surface signs indicating its presence this species is seldom sought for food.

**Other name:** Giant macoma.

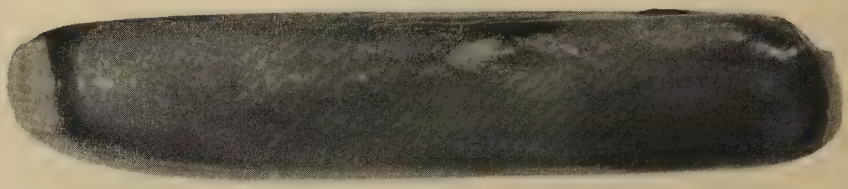

FIGURE 42

## ROSY RAZOR CLAM
### *Solen rosaceus* Carpenter 1864

**Description:** Thin, flat, elongate valves nearly cylindrical with the long margins of the shell straight and roughly parallel. Shell covered with a thin, transparent, glossy periostracum through which the rosy color of the shell shows. Umbos located at extreme anterior end of shell. Siphons united to form a tube and these and the foot frequently protrude from the two ends of the shell. Siphons and foot often darkly pigmented. Attains a length of three inches. Differs from the sickle razor clam by having the long shell margins straight and from the jackknife clam by having umbos near extreme anterior end.

**Range:** Humboldt Bay, California, to Mazatlan, Mexico.

**Habits:** Usually found at depths from a few inches to a foot or more in sandy mud of sheltered bays, sloughs and estuaries. Digs a smooth-lined permanent burrow in which it moves readily up and down. A very active digger and when disturbed can disappear into the sand in a very short time. Capable of a kind of "swimming" though habitually found in burrows. Not common anywhere in California.

**Use:** Taken incidentally by clam diggers usually seeking other species.

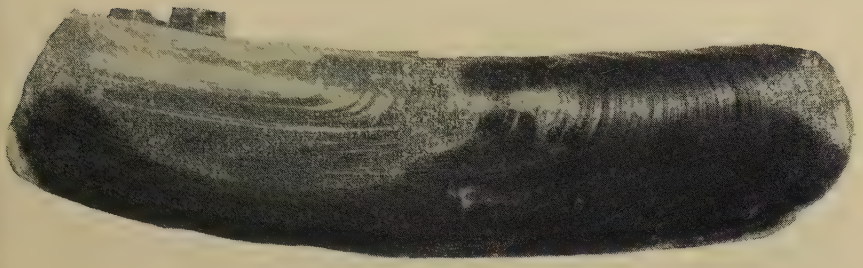

FIGURE 43

## SICKLE RAZOR CLAM
### *Solen sicarius* Gould 1850

**Description:** Thin, flat, elongate, slightly curved valves. Long margins of the shell roughly parallel, anterior end generally flat and posterior margin rounded. Umbos located at extreme anterior end. Shell covered with a heavy, glossy periostracum which gives it a yellowish-brown varnished appearance. Siphons united. Foot frequently darkly pigmented. Siphons or foot or both frequently protrude from the shell. Length to four inches. Differs from the rosy razor clam in having slightly curved shell and from the jackknife clam by having umbo at extreme anterior end.

**Range:** British Columbia to San Quintin Bay, Baja California.

**Habits:** Usually found at depths of one foot or more in firm, sandy mud of sheltered bays, sloughs and estuaries. Digs a smooth-lined, permanent burrow in which it moves readily up and down. Most frequently found under the roots of eel grass and is an extremely active digger. Best localities in California are Elkhorn Slough and Humboldt Bay, though it is rare even at these localities.

**Use:** Taken but incidentally by clam diggers usually seeking other species. More frequently used for fish bait than human consumption.

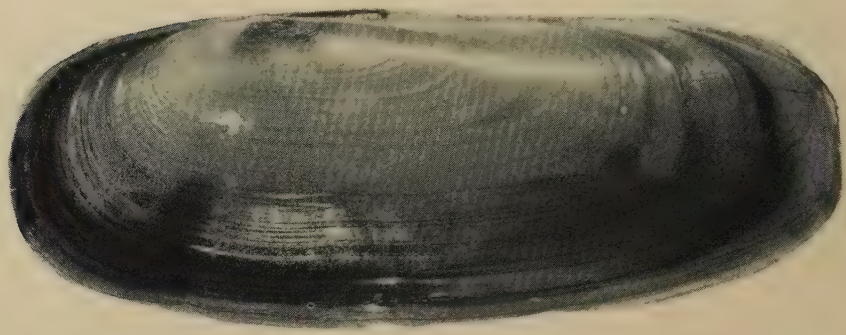

FIGURE 44

## NORTHERN RAZOR CLAM
*Siliqua patula* (Dixon 1788)

**Description:** Elongate shells, thin, flat and smooth; covered with a heavy, glossy, yellowish periostracum, a prominent rib extending from the umbo to the margin on the inside of the valve. Foot large and powerful, never pigmented. Siphons rather short and united except at tips. Umbos nearer anterior than posterior end. Attains a length of seven inches. Differs from the rosy and sickle razor clams and the jackknife clam by having a heavy, raised rib extending from the umbo to the margin of the shell on the inside.

**Range:** Alaska to Pismo Beach, California.

**Habits:** Found on open sandy beaches fully exposed to the pounding surf, particularly those beaches which are broad and flat. Razor clams are extremely active burrowers and may dig to a considerable depth if sufficiently disturbed. When at the surface of the sand the razor clam holds a vertical position with its siphons projecting into the water or air above. When alarmed by vibrations of heavy footsteps or pounding on the sand it withdraws the siphons leaving a characteristic slit-like opening in the sand. It is usually by this slit-like opening that razor clams are located and dug. Best beaches are Pismo Beach, Morro Bay and Clam Beach near Crescent City.

**Use:** One of the finest food clams in California and much sought by sports diggers on beaches where it is abundant. Object of a commercial fishery in states to the north of California.

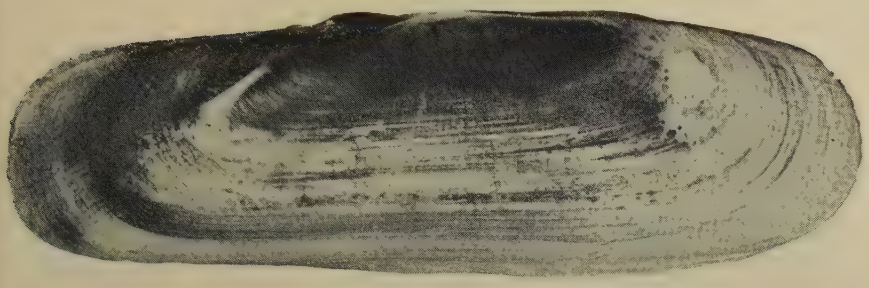

FIGURE 45

## CALIFORNIA JACKKNIFE CLAM
### *Tagelus californianus* (Conrad 1837)

**Description:** Thin, flat, elongate valves with the long margins nearly parallel and the umbo central. Shell greyish-white, covered with a dull, brownish periostracum. Siphons separate and long. Attains a length of four and one-half inches. Differs from razor clams in having separate siphons and a dull periostracum.

**Range:** Humboldt Bay, California, to Panama.

**Habits:** Found in mud or muddy sand of back bays, sloughs and estuaries. Digs a smooth-lined permanent burrow which it fits very snugly and in which it moves readily up and down. This burrow extends vertically downward some 15 to 20 inches. When at the top of the burrow the jackknife clam is about four inches beneath the surface and the siphons reach the water through two small holes which are about an inch apart at the surface. If disturbed the clam pulls its siphons in and moves rapidly to the bottom of the burrow. A special clam dart is used for gathering this species. Not common north of Elkhorn Slough. Best localities are Elkhorn Slough, Alamitos Bay, Anaheim Slough, Mission Bay, San Diego Bay and Tijuana Slough.

**Use:** Though of good flavor this species is seldom eaten. Fished very heavily in Southern California by sport and commercial diggers who use it for fish bait.

**Other name:** Razor clam.

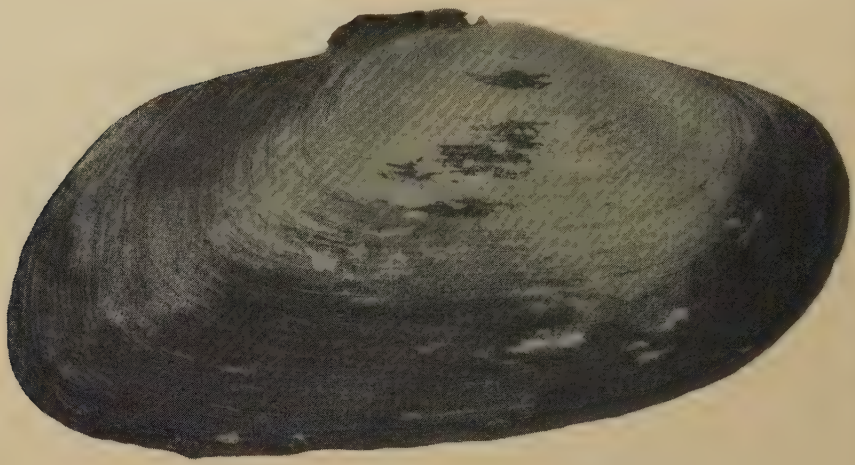

FIGURE 46

## DEEP WATER GARI
### *Gari edentula* (Gabb 1869)

**Description:** Smooth, greyish-white shell without any pinkish or reddish rays radiating from the umbo. Valves elongate, nearly twice as long as wide, covered with a heavy, brownish periostracum which is usually worn off near the center of the valve. Siphons long and separate. Hinge ligament external, large. Attains a length of five inches. Differs from the sunset clam by having umbos nearer anterior end and a length about twice the width.

**Range:** Santa Barbara, California, to San Diego, California.

**Habits:** This species is usually found in the more quiet and sheltered waters along the outer coast at depths of 20 to 80 feet. Mostly taken by commercial fishermen in various kinds of nets but never any great number at one time. Little is known of its life history or burrowing habits but undoubtedly lives within five or six inches of the surface. Indications are that fairly extensive beds of these clams occur offshore from Pt. Dume and Malibu.

**Use:** Considered one of the finest clams on the west coast by the fishermen who have taken and eaten them. Not possible to obtain in any quantity with the types of fishing gear used in the localities where it is most common.

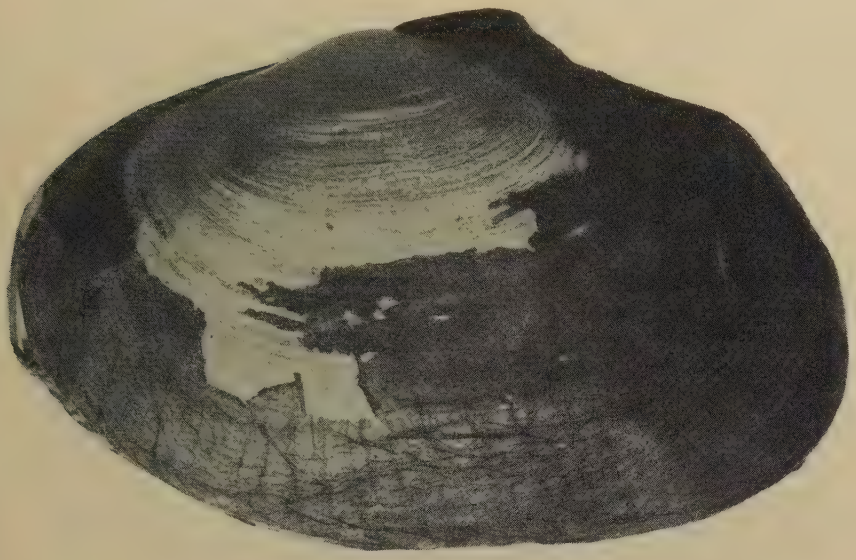

FIGURE 47

## SUNSET CLAM
*Gari californica* (Conrad 1849)

**Description:** Smooth greyish-white shell, oval in outline, often with pinkish or reddish rays radiating from the umbo. Valves covered with a heavy, yellowish periostracum often discolored by grey or black mud stains. Hinge ligament external, large. Valves thin and flattened, not much longer than wide. Siphons long and separate. Attains a length of four inches. Differs from the deep water gari by having centrally located umbos and a length of about one and one-half times the width.

**Range:** Forrester Island, Alaska, to San Diego Bay, California.

**Habits:** Found in sand or sandy mud near the entrances to bays, lagoons and estuaries. Sometimes found in eel grass beds or in the sand under boulders used in breakwater construction. Found at a depth of 6 to 8 inches beneath the sand. Siphons seem to be extended in permanent positions but visible surface signs indicating its presence are extremely difficult to find and recognize.

**Use:** One of the better flavored white-meated clams, but due to its comparative rarity it is not the object of a fishery.

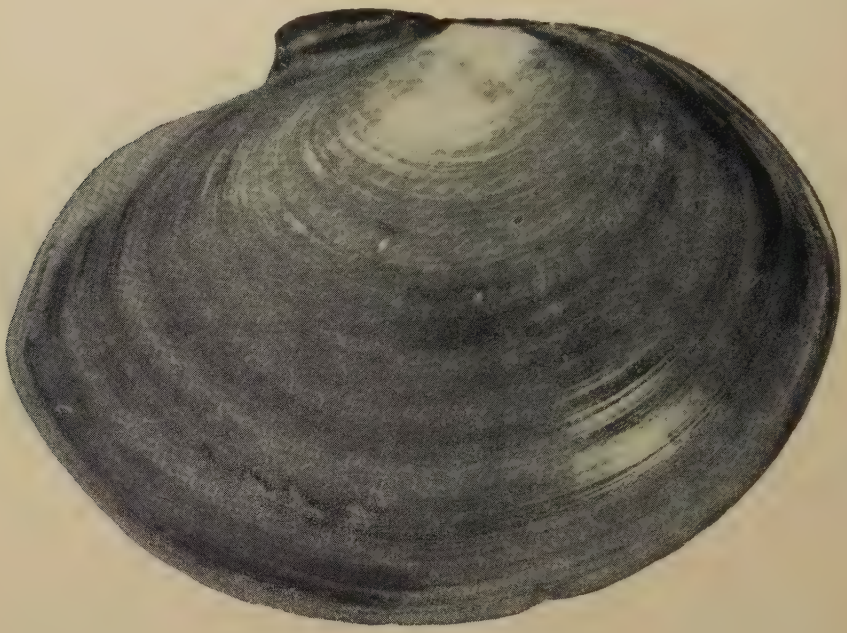

FIGURE 48

## PURPLE CLAM
### *Sanguinolaria nuttalli* Conrad 1837

**Description:** Thin, flat valves almost oval in outline. Right valve flattened more than the left. Outside of shells covered with a thick, shiny, varnish-like periostracum. Interior of shell purplish. Hinge ligament external, large. Siphons separate and quite long. Attains a length of four inches.

**Range:** Elkhorn Slough, California, to Magdalena Bay, Baja California.

**Habits:** Found in sheltered bays, sloughs and estuaries in loose sand or mixed gravel and sand. Particularly common in the entrance channels washed by fast moving tides. Found at depths of 12 to 16 inches beneath the surface of the sand, lying on the right side. Best localities in California are Alamitos Bay, Anaheim Slough, Newport Bay and Tijuana Slough.

**Use:** Though of very good flavor this species is more often used for fish bait than food. Though more common than many species it is not sought by many clam diggers.

**Other names:** Butter clam, varnish shell.

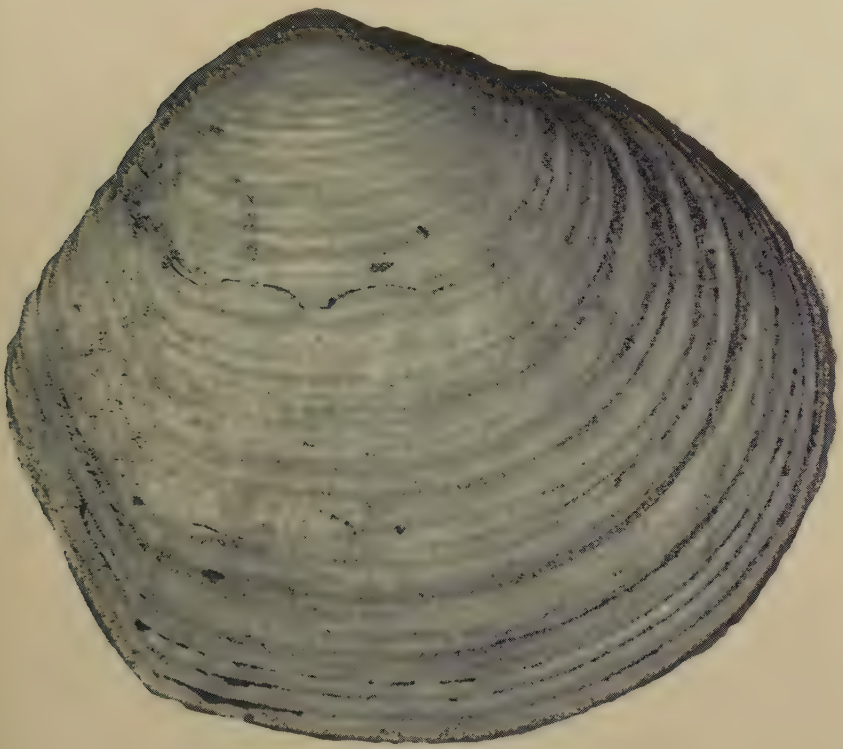

FIGURE 49

## CLIPPED SEMELE
### *Semele decisa* (Conrad 1837)

**Description:** Heavy, compact, nearly round valves ornamented with numerous thick, unequal, wrinkled, concentric ridges. The entire surface covered with fine radial grooves irregularly wrinkled and granulated. Whitish-grey in color with tinges of purple in the concentric grooves. Interior white with purple around the dorsal margin. Attains a length of four inches.

**Range:** San Pedro, California, to Cape San Lucas, Baja California.

**Habits:** Found in coarse sand and gravel under or near boulders and cobbles along rocky areas of the outer coast. Sometimes found in sandy areas in more quiet semi-protected waters of the coast. Sometimes taken in the intertidal area but in California it is more often found in deeper water beyond the intertidal zone. Not common anywhere within its limited range in California.

**Use:** Said to be of good flavor though so seldom taken little is known of its use as food.

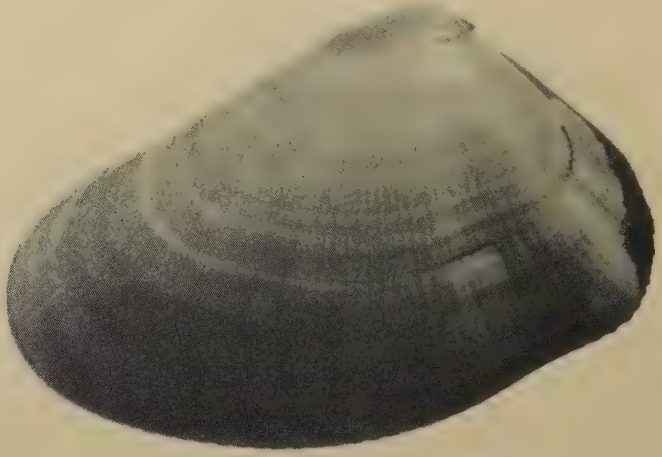

FIGURE 50

## BEAN CLAM
### *Donax gouldi* Dall 1919

**Description:** Shells heavy and strong, deeply arched and marked by indistinct radiating grooves. Older shells have occasional widely spaced concentric "growth" rings cutting round the shell. Margin of valves heavily crenulated forming interlocking teeth on opposite valves. Color patterns extremely variable, chiefly white, yellow, orange or bluish-purple. Attains a length of slightly over one inch. Differs from the wedge clam in having a very thin, transparent periostracum.

**Range:** Pismo Beach, California, to Cape San Lucas, Baja California.

**Habits:** Found at the surface on exposed sandy beaches along the outer coast. These clams are subject to resurgent population increases and during some years they are so numerous they form a solid pavement several layers deep in the intertidal zone. Most of these clams will have colonies of hydroids (hair-like clusters) attached to their shells at the siphonate end and are easily located at low tide by this exposed hydroid. The bean clam seems to live a maximum of three years and entire populations consisting of billions of individuals may disappear completely in just a few days time.

**Use:** During years when extremely common the bean clam is collected in large numbers and steamed for broth. Used in this manner it is unexcelled by any other California species of bivalve. Ordinarily too small in size and too few in numbers to be much sought for food.

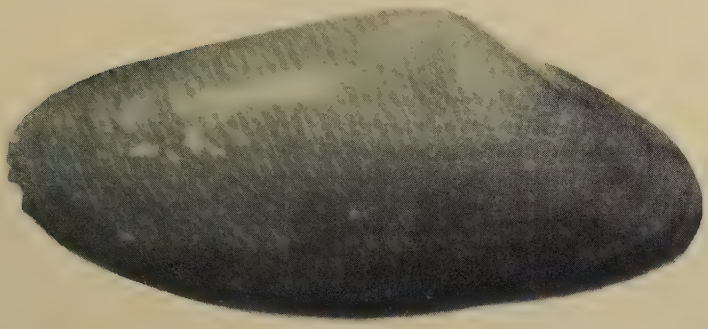

FIGURE 51

## WEDGE CLAM
### *Donax californicus* Conrad 1837

**Description:** Thin, light, wedge-shaped shell with very faint radiating grooves. Heavy, varnish-like periostracum gives shell a yellowish color, otherwise buff where periostracum is missing. Interior of margin finely crenulate. Siphons separate, short. Attains a length of about one inch. Differs from the bean clam by having smooth, hard, varnish-like periostracum.

**Range:** Goleta, California, to Magdalena Bay, Baja California.

**Habits:** Found in sand or sandy mud of bays, lagoons and estuaries and other localities not exposed to pounding surf. Not an active burrower and usually found at or very near the surface. This species is never as numerous as the bean clam but like the bean clam it is subject to resurgent population increases, being extremely common some years in some waters and extremely rare during other years in the same waters.

**Use:** Due to the small size of the wedge clam it is not subjected to very heavy fishing pressure even during years in which it is extremely abundant. Used mostly for broth for which it is excellent.

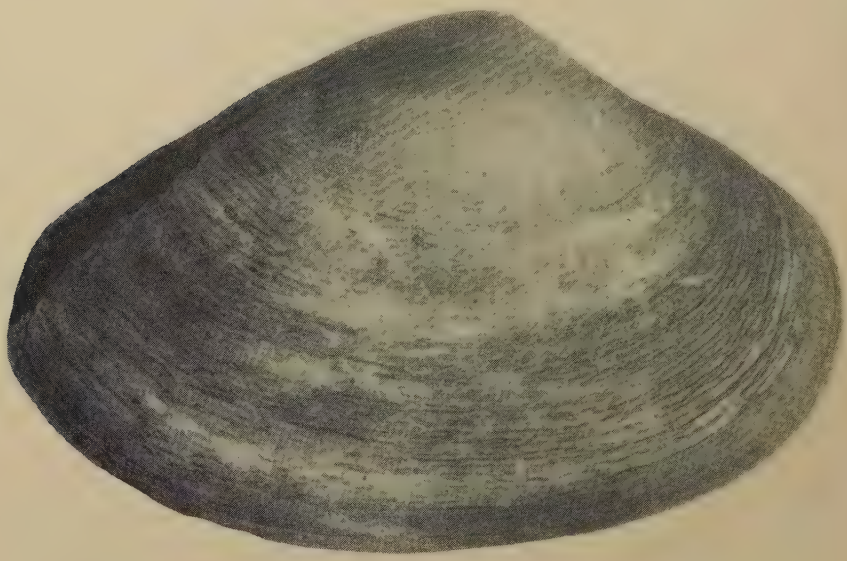

FIGURE 52

## CALIFORNIA MACTRA
### *Mactra californica* Conrad 1837

**Description:** Shells thin, whitish, covered with a brownish periostracum. A heavy fold of epidermis along the postero-dorsal margin of the shell. Shell often appears wrinkled due to concentric folds of periostracum particularly along ventral one-third of shell. Shell margins close tightly. Attains a length of two and one-half inches. Differs from the dish clams and the gapers by having a heavy fold of epidermis along the postero-dorsal margin of the shell.

**Range:** British Columbia, to Magdalena Bay, Baja California.

**Habits:** Lives in fine sand or firm sandy mud, particularly near the entrances of bays, lagoons and estuaries. Not particularly common anywhere within its range.

**Use:** Mostly sought by shell collectors but sometimes taken incidentally by clam diggers seeking other species. Said to be of good flavor.

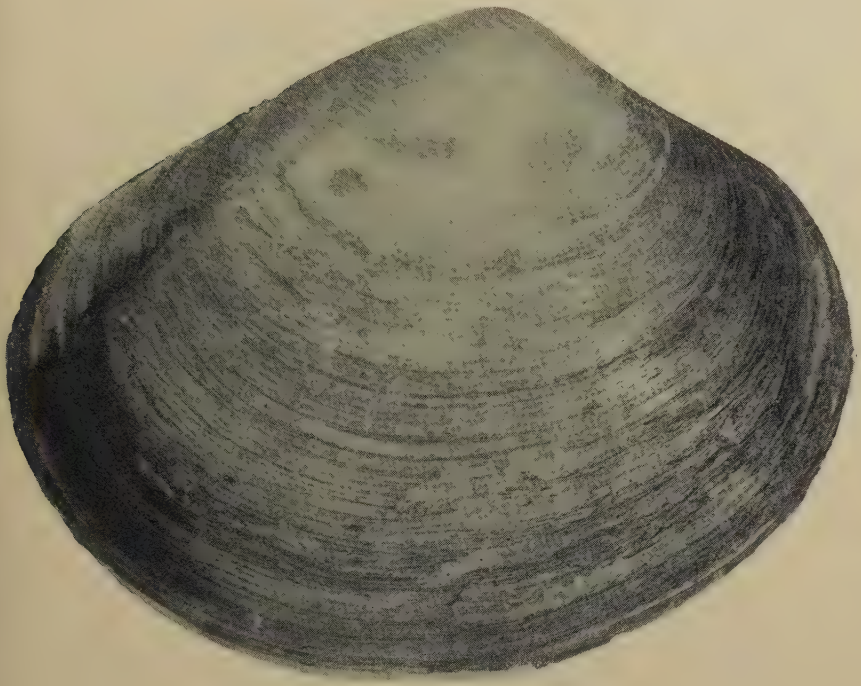

FIGURE 53

## NARROW DISH CLAM
### *Spisula catilliformis* (Conrad 1867)

**Description:** Valves thin, particularly at the edges except in very old specimens where the ventral margin appears thick and laminated. A dull, yellowish-brown periostracum covering the shell where not eroded. Shell ornamented by a single raised rib radiating from the umbo at the posterior end, and numerous, fine, concentric growth lines. Shell margins closed tightly. Attains a length of five inches. Differs from Hemphill's dish clam by having a slightly rounded dorsal slope; from the California mactra by having a rather smooth outer shell along the posterior margin and from the gapers by being able to close tightly along all margins.

**Range:** San Francisco Bay to San Diego Bay.

**Habits:** Lives in fine sand or firm, sandy mud in bays, sloughs and estuaries as well as more quiet sheltered areas along the outer coast. Seldom in water so shallow as to be exposed at average low tides. Not common anywhere within its range.

**Use:** Sometimes taken incidentally by clam diggers seeking other species. Said to be of good flavor.

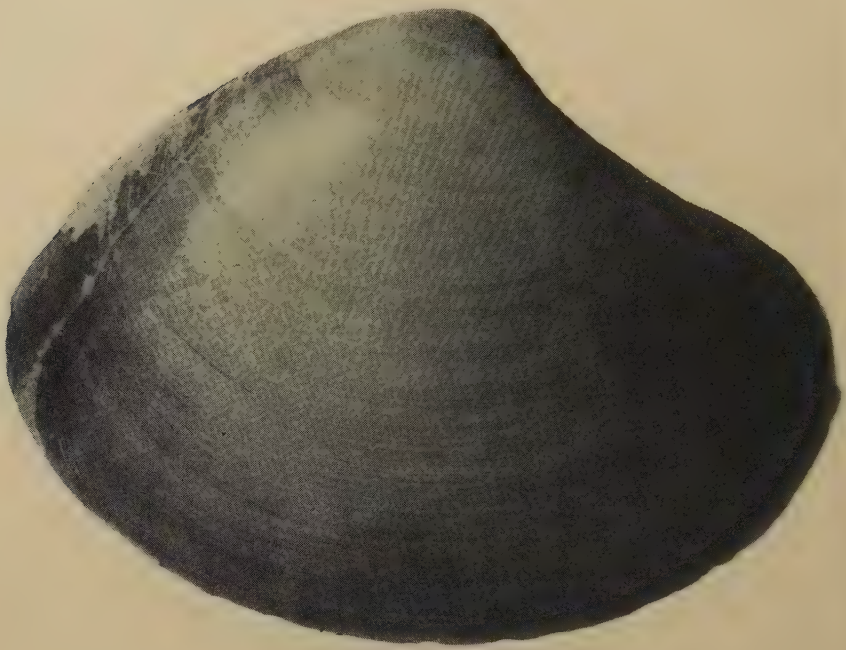

FIGURE 54

## HEMPHILL'S DISH CLAM
*Spisula hemphilli* (Dall 1894)

**Description:** Valves thin, particularly at the edges. A thin, dull, yellowish-brown periostracum covering the shell where not eroded. A single raised rib roughly parallels the posterior margin. Shell otherwise generally smooth except for numerous fine, concentric growth lines. Antero-dorsal slope of the valve distinctly concave. Shell margins close tightly in adults. Attains a length of seven inches. Differs from the narrow dish clam, the California mactra and the gapers in having a concave antero-dorsal slope.

**Range:** Santa Barbara, California, to Ensenada, Baja California.

**Habits:** Lives in fine sand or firm, sandy mud in bays, sloughs and estuaries as well as more quiet protected areas along the outer coast. Seldom in water so shallow as to be exposed at average low tides. Large specimens may be six or more inches beneath the surface. Not common anywhere within its range.

**Use:** Sometimes taken incidentally by clam diggers seeking other species. Said to be of good flavor.

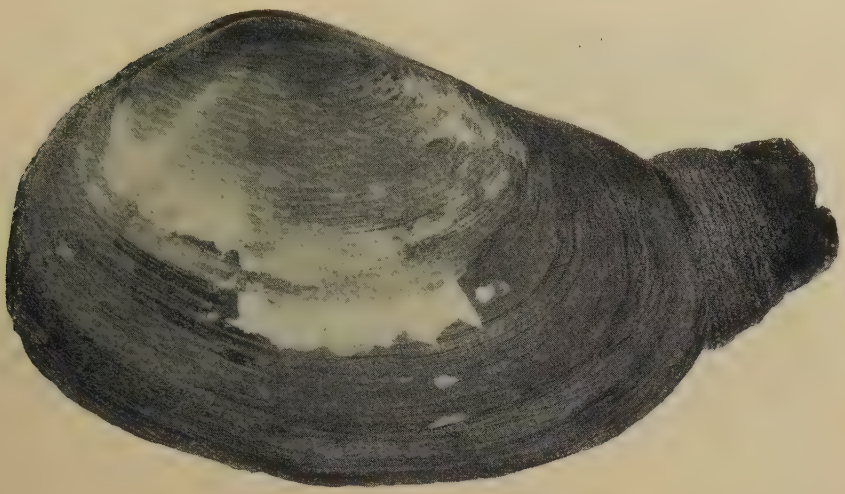

FIGURE 55

## GAPER
### *Schizothaerus nuttalli* (Conrad 1837)

**Description:** Among the largest California bivalves. Valves thin, whitish, covered with a thick, brown periostracum which is often badly eroded on large specimens and may be stained black if clams are living in mud. Siphons united and extremely long, incapable of being retracted into the valves. Siphons covered with a heavy, dark epidermis and tips with a pair of thick cutaneous flaps. Often with small clumps of seaweed growing on siphon tips. Attains a length of eight inches and a weight of nearly four pounds. Differs from the dish clams and the California mactra by having cutaneous flaps on siphon tips and widely gaping shells at posterior end. Its differences from *Schizothaerus capax* are not known at this time. *S. capax* and *S. nuttalli* both occur in Humboldt Bay.

**Range:** Puget Sound to Scammons Lagoon, Baja California.

**Habits:** Lives at depths as great as three feet or more in fine sand or firm, sandy mud in bays, sloughs and estuaries as well as more quiet sheltered areas along the outer coast. Siphons form a tube which extends to the surface of the mud. Sometimes on foggy or cool cloudy days gaper clams will have several inches of their siphons exposed on the surface of the mud. On firm, sandy mud, a round opening an inch or so in diameter indicates the presence of this clam. If disturbed by vibrations of footsteps, etc. the siphons are withdrawn rapidly enough to squirt water several feet into the air. May frequently be located on the mud flats by the squirts of water particularly as the tide comes in. Probably one of the most common clams along the entire coast of California as it ranges from near the high tide line into water over 100 feet deep. Best localities: Alamitos Bay, Morro Bay, Elkhorn Slough, San Francisco Bay, Tomales Bay, Bodega Bay and Humboldt Bay.

**Use:** Highly esteemed for food and the object of a heavy sportfishery, particularly in Central and Northern California.

**Other names:** Summer clam, horse clam, otter shell, horse neck clam, big neck clam.

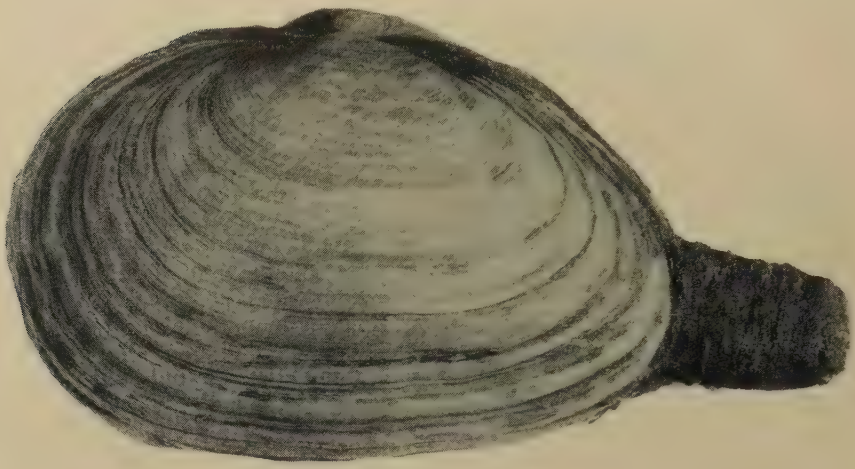

FIGURE 56

## SOFT-SHELL CLAM
### *Mya arenaria* Linnaeus 1758

**Description:** Valves oval in outline, whitish, sometimes stained grey or black from the mud in which they live. Shell light and brittle with no external sculpturing other than occasional concentric growth lines. Umbos central with a spoon-like projecting tooth or cartilage pit near the umbo on the inside of the left valve. Siphons long and united covered with heavy epidermis, incapable of being completely withdrawn within the valves. Length to five inches.

**Range:** British Columbia to Elkhorn Slough, California.

**Habits:** This species was accidentally introduced into California with shipments of Eastern oysters and was first detected in California in 1874. On our coast it is usually found in heavy, black mud in back waters of bays, lagoons and sloughs where there is some mixing of fresh water with sea water. Usually ten or more inches beneath the surface with the siphons extended to the surface. Siphon holes appear slit-like at the surface of the mud flats and once recognized are easily located. Best localities: Elkhorn Slough, San Francisco Bay, Tomales Bay, Bodega Bay, Humboldt Bay in back areas near influx of fresh water.

**Use:** Highly esteemed for food and the object of extensive sport and commercial fisheries. In years past this species was cultivated to a limited extent in the San Francisco Bay area.

**Other names:** Soft clam, long clam, mud clam, sand clam.

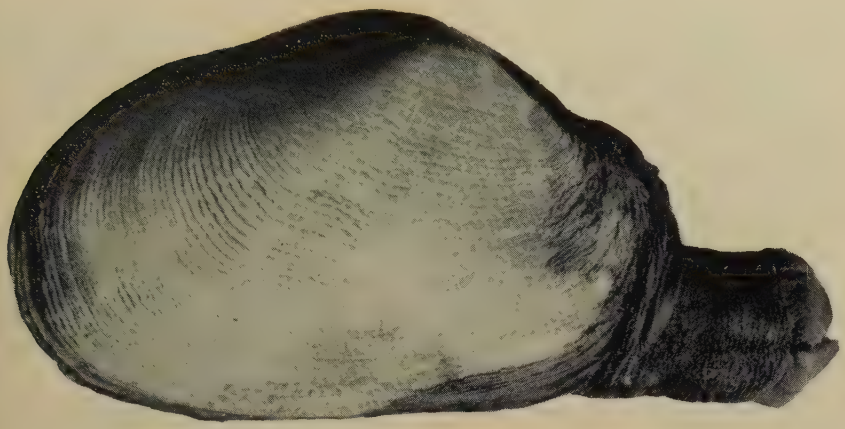

FIGURE 57

## CHECKED BORER
### *Platyodon cancellatus* (Conrad 1837)

**Description:** Valves widely truncated and gaping at posterior (siphonate) end. Shells whitish, sculptured with concentric evenly spaced ridges. Siphons long and united to form a tube the exterior of which is covered with a yellowish-brown skin or epidermis which extends onto the posterior end of the shell. Interior of left valve with a spoon-like projecting cartilage pit near the umbo. Heavy epidermis at siphon tips has the appearance of a "+" mark. Attains a length of three and one-half inches.

**Range:** Queen Charlotte Islands, British Columbia, to San Diego Bay, California.

**Habits:** Lives in heavy clay or soft rocks near the entrances to bays, lagoons and estuaries and often in more or less exposed situations along the outer coast. Excavates its burrow as it grows. Seldom deeper than four or five inches with siphons extended to the surface. Sharp vibrations will cause these clams to withdraw their siphons rapidly enough to eject a small stream of water a foot or so into the air. The check or plus mark on the siphon tip will identify this species from all other rock or clay borers. Not common along most of its range but may be found in fair abundance in some spots between San Pedro and Redondo Beach.

**Use:** Due to its comparative rarity this species is seldom sought for food. It is of fine flavor and excellent in chowder. Sometimes used for fish bait.

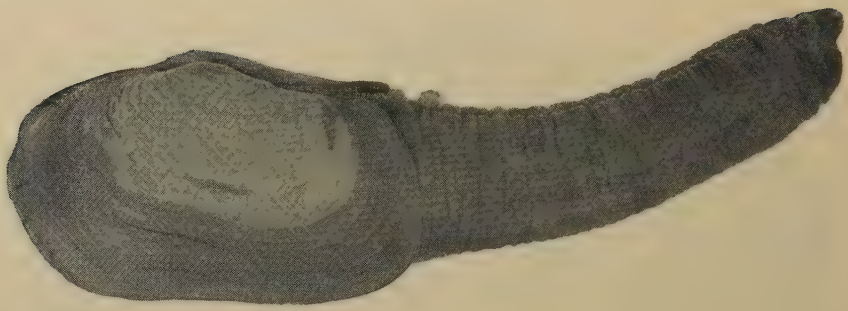

FIGURE 58

## GEODUCK
### *Panope generosa* (Gould 1850)

**Description:** Shells whitish, covered with a dull, yellowish-brown periostracum which is often badly eroded in large specimens. Shells sculptured with a number of unevenly spaced, concentric growth lines. Siphons united to form a tube, extremely long and impossible to withdraw into the shells. Valves gape widely on all sides except dorsal (hinge) area. Flesh exposed between the gaping valves covered with a heavy reddish-brown epidermis or skin. Shell attains a length of seven inches, with reputed weights for the entire animal of more than eight pounds. Differs from the gapers for which it is often mistaken by not having cutaneous flaps at siphon tip.

**Range:** Forrester Island, Alaska, to Scammons Lagoon, Baja California.

**Habits:** Lives in sandy mud of bays, sloughs and estuaries at depths of four or more feet. Siphons reach the surface through a smooth hole. At low tide these clams may be located on mud flats by columns of water which they squirt several feet into the air. They may be also located by the siphon hole which is an inch or more in diameter at the surface of the mud. When the extended siphon is touched it is seldom withdrawn so rapidly as to squirt water into the air. Not common in California but may be found in some numbers at Morro Bay.

**Use:** One of the finest food clams in California but due to its comparative rarity and the difficulty involved in excavating for a single clam it is not often sought.

FIGURE 59

## WART-NECKED PIDDOCK
### *Pholadidea ovoidea* (Gould 1851)

**Description:** One of the largest of the boring clams found on our coast. Thin, whitish, much inflated shells sculptured with concentric ridges at the siphonate end which is separated from the roughened anterior end by an oblique groove. Ventral margins of the valves meeting only at the center. Anterior end open and foot protruding during active burrowing stage and shelled over during later stages when full growth has been attained. Siphons united, extremely long, covered with a brownish epidermis at the base otherwise white with elongate flecks of chitinous material scattered over the exterior giving the siphons a warty appearance. Clam incapable of withdrawing siphons into valves. Length of shell to five inches. Differs from all other pholads by having chitinous "warts" on siphons.

**Range:** Santa Cruz, California, to Turtle Bay, Baja California.

**Habits:** Bores into clay, shale, sandstone or other soft rock on the open coast sometimes to depths of 20 inches. Siphons extend to the surface through a tapered passage which may be an inch in diameter at the surface of the rock. This species can be identified without breaking the rock by the large, mottled, reddish-purple siphon tips. Found in abundance only at Carpinteria and near Santa Cruz.

**Use:** Because of the habitat few people have the patience to chisel a large specimen out of the rock. Of excellent flavor and as few as two large clams will feed an average family.

FIGURE 60

## MUD PIDDOCK
### *Barnea pacifica* (Stearns 1873)

**Description:** Shell cylindrical, delicate, white in color and ornamented with distinct, concentric growth lines and faint radiating ribs. Siphons long, united and covered with a heavy, brown epidermis. Small tubercles at the junction of the concentric and radiating lines, particularly at the anterior end. Incapable of withdrawing siphons completely into shell. Shell attains a length of three and one-half inches. Differs from rough and wart-necked piddocks by having a heavy epidermis over entire siphons and from other piddocks by not being able to withdraw siphons into shell.

**Range:** San Francisco Bay, California, to Peru.

**Habits:** Lives at depths of 10 or more inches in heavy mud of bays, lagoons and estuaries. Siphons extend to the surface through a smooth lined burrow and are slowly withdrawn when the animal is disturbed. These piddocks usually live in small colonies of up to 20 individuals and may be located by finding the tiny round siphon openings in the surface of the mud. The shells are so fragile that digging by hand is necessary to avoid breaking them. Not common anywhere in California but can be obtained in some numbers in Alamitos Bay.

**Use:** Due to its comparative rarity it is seldom sought for food. Unless thoroughly cleaned these piddocks have a muddy taste.

FIGURE 61

## ROUGH PIDDOCK
### *Zirfaea pilsbryi* Lowe 1931

**Description:** Shells whitish, elongate, gaping widely at both ends. The smooth siphonate end separated from the roughened anterior end by a diagonal groove. Anterior end with numerous sharp projecting spines or teeth where concentric growth lines join radiating ridges. Siphons united and quite long, covered with a thin epidermis near the junction with the shell. Small, rounded flecks of horny material spotted irregularly over surface of siphons which cannot be withdrawn completely into the shell. Shell attains a length of five inches. Differs from the mud piddock by having a groove separating anterior and posterior ends; from the wart-necked piddock by having rounded spots on siphons and from other piddocks by not being able to withdraw its siphons into its shell.

**Range:** Nunivak Island, Alaska, to San Juanico Bay, Baja California.

**Habits:** Lives at a depth of 10 to 14 inches or more in heavy mud, clay or soft rocks in bays, lagoons and estuaries. Sometimes in soft rock along exposed areas of the open coast. Siphons are extended to the surface through a smooth, tapering hole and are slowly withdrawn when the animal is disturbed. Siphon holes are round and about a half inch in diameter, difficult to tell from some shrimp and crab holes. These piddocks are extremely slow burrowers and cannot escape in this manner. Best localities in California: Elkhorn Slough, San Francisco Bay, Bodega Bay, Tomales Bay, Humboldt Bay.

**Use:** Primarily used for food but because of the habitat in which it lives it is seldom sought by clam diggers. Should be thoroughly cleaned before eating to avoid a muddy taste.

FIGURE 62

## SCALE-SIDED PIDDOCK
### *Parapholas californica* (Conrad 1837)

**Description:** Almost pear-shaped in outline. Anterior end of the shell rounded and much roughened. Siphonate end much smaller, the sides covered with overlapping plates of brownish epidermis. Siphons long, united to form tube with reddish pigmentation at tip. Anterior end open and foot protruding during active burrowing stage and shelled over during later stages when full growth has been attained. Two long, narrow, shelly plates cover the dorsal and ventral margins. Attains a length of six inches. Differs from the mud, rough, and wart-necked piddocks by being able to withdraw siphons into shell and from the flap-tipped piddock by having overlapping plates along sides of posterior end of shell.

**Range:** Santa Cruz, California, to Turtle Bay, Baja California.

**Habits:** Bores into clay, shale, sandstone or other soft rock on the open coast. Large animals are sometimes buried eight inches or more. Siphons extended through a narrow passage to the outer surface of the rock where they are readily recognized by the purplish-red color of the papillae at the siphon tip. In soft rock areas where small, round holes suggest the presence of these clams a sharp blow on the rock with a hammer will cause the plate-sided piddock to squirt water out of the holes, saving much time in locating live clams. Best localities are Point Fermin, White Point, Carpinteria and Santa Cruz.

**Use:** Due to the habitat in which it lives it is seldom sought. Sometimes this specicies has a hot peppery flavor but mostly is rather mild and quite good. Sometimes used for fish bait.

FIGURE 63

## FLAP-TIPPED PIDDOCK
### *Penitella penita* (Conrad 1837)

**Description:** Shell thin, whitish, globular at the roughened anterior end and tapering rapidly to the posterior end. Dorsal hinge covered with a triangular-shaped accessory plate. Anterior end open and foot protruding during active burrowing stage and shelled over during later stages when full growth has been attained. At the time the anterior end shells over an elongate chitinous flap is formed at the tip of each shell. Attains a length of four inches. Differs from the mud, rough and wart-necked piddocks by being able to withdraw siphons into shell and from the plate-sided piddock by having chitinous flaps at posterior end in adult stages.

**Range:** Chirikof Island, Alaska, to Turtle Bay, Baja California.

**Habits:** Bores into clay, shale, sandstone or other soft rock on the open coast. Seldom deeper than five inches, siphons extended to the surface of the rock through a narrow passage. In soft rock areas where small round holes suggest the presence of these clams a sharp blow on the rock with a hammer will cause the flap-tipped piddock to squirt water from the siphon hole. Frequently found in the same rock formation as the wart-necked and plate-sided piddocks, the checked and pea-pod borers and the rock-boring mussel. Best localities are Point Fermin, White Point, Carpinteria, Santa Cruz and Buhne Point in Humboldt Bay.

**Use:** Because of the habitat in which the flat-tipped piddock lives it is seldom sought. A rather mildly flavored clam and quite good in chowder. Sometimes used for fish bait.

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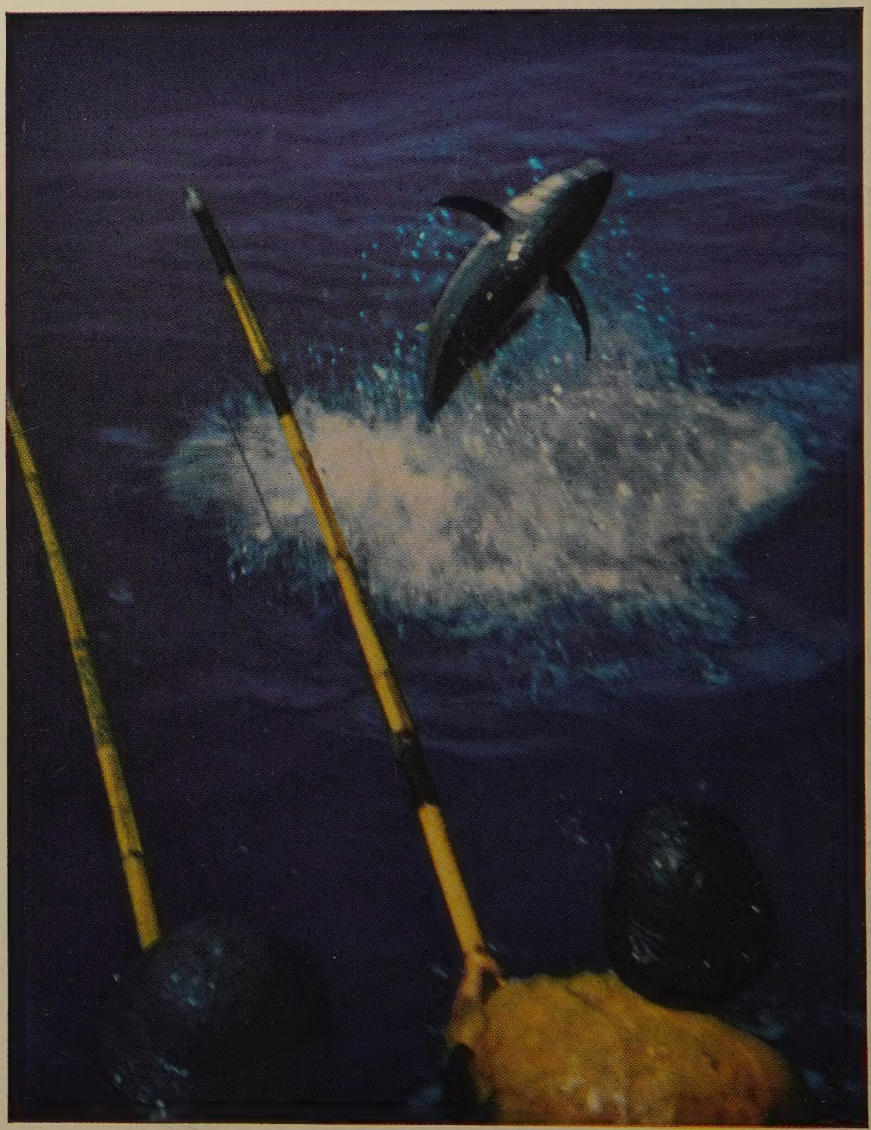

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